Lessons From Engineering Council For the New Federation

TWO questions which are bound to enter the mind of any engineer considering the pros and cons of the Federated American Engineering Societies are these: "If Engineering Council is a success, why should the proposed Federation supplant it? On the other hand, if Engineering Council is a failure, why should the Federation be organized along lines so nearly parallel?" Undoubtedly these thoughts were in the minds of many delegates to the organizing conference held last month in Washington, even if they were not directly stated on the floor, for at least three very influential delegates spoke in defence of Engineering Council, denying its ineffectiveness, yet explaining why it had not attained full measure of success.

It should be immediately pointed out, however, that the second question involves detailed information of the constitution, organization and personnel of both the Council and the Federation—upon inquiry it may be established that the two bodies are fundamentally different and the premise stated in the query therefore entirely unjustified. Such an investigation is not the present object; it is rather to inquire into the reason why Engineering Council did not attain its expected amount of influence. This known, some of the reefs and shoals along the course of the new organization will be charted, and a voyage steered accordingly.

Engineering Council, it will be recollected, is the child of the United Engineering Socities, which, in turn was formed by the four so-called Founder Societies— Civil, Mining, Mechanical and Electrical Engineers— and, quoting their official literature is an "organization of National Technical Societies of America, created to provide for consideration of matters of common concern to Engineers, as well as those of public welfare in which the profession is interested, in order that united action may be made possible." The American Society for Testing Materials and the American Railway Engineering Association are also member societies. The executives of each of the member societies appoint representatives, who have subdivided their number into various committees, the personnel of which do whatever is done along their delegated line of activity. Their funds have been meager, being limited to some $13,000 annually contributed by the member societies.

Well informed engineers have characterized Engineering Council as an imposing body which did nothing. This is doubtless too harsh a criticism, for the Council has done a great deal of good work—much of it in a pioneering way, by trial and error. Yet unquestionably there has not been the activity in any line that was expected nor hoped. By its mode of organization about all it could do was to start the ball rolling along a desired path, and

it had no means of reaching out into the great body of engineers in this country to get them behind the ball and keep it rolling faster. Consequently and naturally it settled back into rest.

In other words, the insurmountable defect in Engineering Council was its lack of connection with the "rank and file." All its admitted shortcomings can be ascribed to that one fact. The individual engineer knew very little about Engineering Council—he had no part in its actual organization beyond his collective urge that engineers organize nationally for economic ends. If he knew anything at all about Engineering Council, he probably felt that it should actively prosecute welfare work without any further help from him; was it not the body of men selected to do that particular job? Being thus built from the top down, it had an imposing head, but lacked a numerous body of men intelligently interested in its aims. Lacking this, is lacked the necessary funds even to operate effectively, let alone to sustain and widen the interest. Consequently only the close insiders actually knew what those at the head were doing, or what difficulties they were encountering.

A moral can easily be drawn from this little bit of history. The new Federated American Engineering Societies must have the interest of its ultimate members—the individual engineer. Only if it has this in good measure can any great success be attained. Its organization should be unrestricted, so that necessary movements may not be hampered; yet on the other hand, the organization should not be magnified as is the clear tendency in the large national societies to a point where it will be nothing but a large income with little net output except printed matter. Frequent and ready circulation from the top down, and the bottom up, is as necessary for right action, as good blood and exercise is for clear thinking.

Colorado Breaks With The Bureau of Mines

UNENVIABLE notoriety is again the portion of the Colorado School of Mines in forcing upon the Bureau of Mines a decision to sever relations between the two institutions and remove the Golden station of the Bureau from the State of Colorado. A report of the break appears elsewhere in this issue. Rumors differ as to whether the action was precipitated by President Alderson or by the Board of Trustees, but the official communication delivered to the superintendent of the station by Acting President Palmer, Alderson being absent in Europe, lays the responsibility at the door of the Board. That may be an inconsequential detail; but there is no question as to the temper of the mining and metallurgical leaders of the State regarding the inconsiderate folly of the act which has deprived Colorado of

federal recognition and co-operation. While they regret the loss they can only endorse the Bureau's decision and hope that some day Golden will clean house and restore to the School of Mines the prestige which it formerly enjoyed and which is still the pride of early graduates.

Golden may argue that it did not eject the Bureau, but that it suggested merely a change of quarters from Engineering Hall to the experimental mill. The transparency of this subterfuge will be evident to those who are familiar with the location of the mill in the creek bottom and its unfitness for use in the delicate and exact scientific work conducted by the Bureau. Perhaps this was an adroit and cunning attempt to turn to some useful purpose a building that has always been a white elephant! However that may be, the Bureau will have no difficulty in finding welcome quarters in some other State, but it is a pity to interrupt important work and spend money in the unpleasant task of moving a large laboratory to a new location where the process of taking root and resuming investigations must be repeated.

Chemical Societies
In Industrial Works

WE ARE indebted to Dr. GEORGE E. EWE, chief chemist for the H. K. Mulford Co. of Philadelphia, for an interesting outline of a chemical society organized and maintained within that company's pharmaceutical and biological establishment. It began in June, 1914, with membership open to any employee, but preferably to those having chemical training. It meets on Friday afternoons whenever called, and papers relating to general and specific subjects are presented; discussions are held, the chief business of the meeting to follow is announced, and so are any new processes or products undertaken in the works.

The results have been, he assures us, very encouraging. A wide variety of subjects has been presented and considered, most of which, of course, have a pharmaceutical turn. And quite apart from the illumination contributed by the various papers, the discussions have proved to be helpful in co-ordinating the various departments and in establishing an *esprit de corps* throughout the organization.

The difference between an establishment in which all the members of the staff are interested and curious, where all pull together, and one in which each person works for the pay there is in it but without either interest or good will, is sometimes described as "all the difference in the world." The expression is hardly adequate. If members know what their fellows are doing this begets teamwork. The opportunity to talk things out and learn the reasons why things are done is the best possible insurance against misunderstandings. And misunderstandings are the worst of nuisances. Innovations may be presented and explained and the consequent rumble of grumble over anything new is avoided. It also gives a man who is not in an executive position a chance to suggest betterments where the operating force can hear them, and if the operating force feels convinced that the proposed changes are needed it makes a more forceful impression upon the main office if the staff recommends it than if the man who originates the idea tells it to the wrong person in authority. Again, if new instructions are given, whether they be of a general or a specific nature, they

can be explained to substantially all to whom they should be explained. Sometimes an otherwise excellent man will get a grouch over any kind of a proposed change, but he can't very well hold fast to his grouch when everybody else understands and favors the measure. One of the greatest advantages of a works chemical society is that its members get to know one another, and personal acquaintance of this sort helps to avoid disputes. "How can I hate a man," asked CHARLES LAMB, "if I know him?" And it gives a scientific turn to the scientific men who spend their days in an industrial concern engaged in scientific work.

We have come across a number of these chemical societies within works of late, and usually they are of great value. That is, they are, unless they are dead. Sometimes such societies haven't anything but a name, like the "chemical laboratory" in a boarding school for young ladies that was exhibited to us with gusto to prove how progressive the head mistress was. It *was* a laboratory in design, but on closer observation we noted that it lacked gas and water connections and that the enclosed spaces were used for the storage of stationery. We have seen "research laboratories" very much like that, too. But a live chemical society within an establishment is worth while, if the establishment is not too small. We are not sure whether bigness may serve as an inhibition or not, but wherever it is feasible to establish such an organization we believe it is worth while. The main thing is that it be a live institution to arouse the scientific interest of the technically trained men employed. Such societies have to find themselves and find their proper level. The meetings in the research laboratory of the General Electric Co., for instance, would doubtless be over the heads of some technologists. So would those at the Mellon Institute or the Tuesday afternoon symposia at the Little laboratory in Cambridge. It is a delicate task to organize such a society, making it neither too high for the interest of its restricted number of members nor too low for their self-esteem. But it is a good thing to have.

British Nitrogen
Production Plans

DURING the war Great Britain, like the United States, laid elaborate plans for fixing atmospheric nitrogen; but owing to confusion and delays the projected plant failed to materialize before the Armistice removed the immediate necessity for its construction. The result, as Mr. HAMER explains elsewhere in this issue, was that Billingham amounted to little more than a site, a few roads, some foundations and temporary structures. While this is in sharp contrast to our own Muscle Shoals, it is not certain that the United States is now in nearly so happy a position as Great Britain when their respective post-war nitrogen problems are concerned. The British have solved theirs, while ours not only remains unsettled but has become a basis for controversy.

Having no war-time investment in a plant of questionable present use and value, the British found no insuperable obstacle to an arrangement with Brunner, Mond & Co. whereby that firm has organized Synthetic Ammonia & Nitrates, Ltd., to acquire Billingham, retain the Government's technical staff and proceed with the erection of a plant for the synthesis of ammonia. British national safety is thus amply assured, and a

happy solution is apparently reached for domestic production of fertilizer and, if needed, explosives.

In addition to this arrangement between the Government and private industry, announcement is made also of a new British company which has purchased rights for the Claude high-pressure process, for which claims of unusual economy are made. No operations have been started in England but the projected plant will add greatly to Britain's independence in nitrogen fixation for both peace and war.

The Philosopher's Opinion
Of the Scientist

THE responsibility of the chemist and his obligation to civilization come to our attention with increased force in the words of the great English philosopher and mystic, WILLIAM RALPH INGE, as delivered before the Chicago Chemists Club by JOHN SMALE, of Lewis Institute. In speaking of the future of the human race Inge says: "Science, I think, is our best hope."

This confirmation by an enlightened man of the scientist's opinion of his calling must be considered something more than a mere idea in the abstract. It assigns to him the task of developing and expressing that which is within for the advancement of the race to higher things, rather than the baser and more usual labor of securing something from without. It classifies him as a producer wholly above the overcrowded realm of sycophantic beings who seek returns without creative effort. It is a position to be envied above all others, and once attained, can be held only by continual introspection for the prevention of parasitic or piratical tendencies.

Organized Labor and
The Steel Industry

THERE is a new turn in labor union affairs as relates to the great stumbling block, the iron and steel industry. The American Federation of Labor and the Amalgamated Association were "on the outs" as to jurisdiction, but the latest news is that the differences have been adjusted, or rather compromised. As to the method, report has it that Mr. GOMPERS has accorded the Amalgamated Association a 51 per cent vote on the general committee for organizing iron and steel workers authorized at the recent Montreal convention, to succeed the committee of the federation which conducted the late strike in the industry.

Presumably this arrangement was made because it was the best that Mr. GOMPERS could get. The Amalgamated Association's officials had ambitions looking to the whole industry being organized by that body, but Mr. GOMPERS could well say to it "Go get a reputation," as of late it has controlled only portions of certain branches of the industry, a really insignificant percentage of the whole.

It should be generally understood that this matter of attempting to "organize" the iron and steel industry is a very important one to the American Federation of Labor. This is not, by any means, because the industry offers a fertile field for the organizers. The federation management knows quite well, from past experience and from scrutiny of present conditions existing, that it does not. What it does see, as was frankly admitted at the annual convention of the fed-

eration in June, 1918, when it was resolved to attempt to organize the iron and steel industry, is that this great nonunion industry stands as the greatest barrier to the further progress of the federation's movement. Why should any nonunion industry be organized if the iron and steel industry is not? If that industry can remain nonunion, so can the others. The industry is a positive force for nonunionism or the open shop. If the industry could be made simply to disappear entirely, that would be the next best thing to its becoming union.

Rumors are thick, and probably correct, that the organizing attempt will be directed wholly or very largely against the United States Steel Corporation, which makes about 44 per cent of the country's steel, rather than against the industry as a whole. The management of the United States Steel Corporation should feel complimented, as doubtless it does, though the compliment is one it could be comfortable without. It being a case of a stumbling block, the singling out of the Steel Corporation is suggestive that the bid of the Steel Corporation for the loyalty of its workmen is particularly high.

If that is the case, however, what has the American Federation of Labor, or the Amalgamated Association, which it is understood will be a 51 per cent factor in the organizing campaign, to offer in competition? As to money, the iron and steel workers know they are well paid, by comparison with rates paid in other industries, and very much so by comparison with the wages paid for many months past to large classes of railway employes. As to social service, playgrounds, visiting nurses, hospitals, home gardens and other things, the iron and steel industry, including the ore and coke branches, has done a great deal. Only recently the Steel Corporation has put into operation a system whereby any one of its employees can own his own home, by paying down 10 per cent of the cost price and paying the remainder from his wages.

The organization methods employed in connection with the iron and steel strike of last September are wholly to be condemned, but from the practical standpoint they offered the best chances of success, and yet the affair failed. The appeal was to the least intelligent of the workers and there does not seem to be any means whereby those men can be fooled again, while as to the skilled men, they are in the main very well contented.

The Relative Demand
For Cooks and Chemists

IT HAS been remarked lately that the day of the chemist has arrived; in fact some of us were of the opinion that it was already high noon. There is evidence, however, from some quarters that the dawn is just breaking. For example the Civil Service Commission of New York City would like very much to find a first-class cook; and for culinary ability of a sufficiently high order it will pay a stipend of $2500 per annum. Likewise the city is in need of the service of a chemist skilled in food and drug examination, but his value is marked down to $1800 per annum. Proceeding further we discover that a competent laboratory assistant in pathology may secure a fine position at $950 per annum. Comparisons are odious; but no one doubts that we need good cooks.

Western Chemical & Metallurgical Field

Smelters Not Responsible for Smoke Nuisance in Salt Lake City

For several years past Salt Lake City, Utah, has been vieing with Pittsburgh for the distinction of being the smokiest city in the world. Many of the influential residents believe that the nearby smelters contribute appreciably to the smoke nuisance, on the theory that the gases discharged from the smelter stacks float over the city in a heavy blanket which prevents smoke from the city chimneys from rising.

It may be remembered that the Garfield smelter of the American Smelting and Refining Co. is sixteen miles west of this city, the Murray smelter of the same company is eight miles south, and the Midvale smelter of the United States Smelting Company, twelve miles south. The smoke conditions at the two latter plants were discussed in detail in CHEMICAL & METALLURGICAL ENGINEERING for June 23, 1920, page 1145. While conditions at the Garfield smelter are not nearly so good, under normal operating conditions a relatively small amount of solid matter is discharged from these stacks. The toxic constituent of the discharge is SO_2, yet it was shown in the article just quoted that even in the opinion of a critical judge sulphur dioxide in the concentration caused by the two lead smelters is not injurious to either animal or vegetable growth, even in their neighborhood.

From a large number of determinations made by the Bureau of Mines it is shown that the sulphur dioxide in the air in Salt Lake City is the result of the combustion of soft coal on the spot. Even at worst the concentration of sulphur dioxide is at no time large enough to be an important factor.

The most interesting feature of this investigation, however, was an experiment made to test the theory that a blanket of sulphurous gas existed over the city. To determine this point analyses of upper strata of the atmosphere were made by the aid of an aeroplane. It was necessary to modify the standardized analytical procedure owing to lack of room for the apparatus and opportunity for its manipulation. Consequently samples of air were taken in the following manner:

Six brown glass bottles of 8 l. capacity were employed. These were charged immediately before the flight with 100 c.c. of a starch solution colored with iodine, and corked with rubber stoppers containing a glass tube closed by a rubber tube and pinch cock. The bottles were then evacuated to a pressure of one inch of mercury, and the pinch cock closed.

Trouble was encountered due to unequal decolorization of the starch solution, but this was eliminated after a thorough cleaning of the bottles and after a strong blue starch solution had been kept in the bottles with frequent shaking for several days.

These bottles were then fixed to the aeroplane fusilage and a flight made on a cloudy day when wind was blowing directly from the Garfield smelter. The top of the smoke cloud at that time was about 2,000 ft. above the city. Three samples of air were taken, the first at an elevation of 2,200 ft., the second at 3,000 ft. and the third on the descent at 1,000 ft. Sulphur dioxide was found in only one sample; at 2,200 ft. the air contained 0.2 part per million.

This meager data serves to substantiate the reasonable prepossession that no heavy blanket of sulphur smoke of high concentration was hanging over the city—at least at any level below 3,000 ft.! The day was typically smoky and undoubtedly conditions were not radically different from the other smoky days during that winter, consequently G. St. John Perrott of the Bureau of Mines' staff absolves the smelters from complicity and ascribes smoke conditions in Salt Lake City to combustion of industrial and residential fuel.

Golden Ejects Bureau of Mines Station

Those interested in the activities of the Bureau of Mines, especially the work in rare metals and the most excellent results in radium and radio-active metals achieved by its personnel in Colorado, will be surprised to know that this station now finds itself homeless as a result of precipitate action by authorities at the School of Mines.

It will be recalled that several years ago, the Bureau's activities were not as widely scattered as at present; in fact, when the Colorado Station was organized in 1910, it was one of the first four, the others being at Pittsburgh, Urbana and Salt Lake City. For five years it was housed in the Foster Building, Denver, and under the direction of Dr. R. B. Moore, now chief chemist of the Bureau, prosecuted very successful work on radioactivity and other problems.

In 1915 the Board of Trustees of the State School of Mines offered the Bureau the free and exclusive use of a three-story building on their campus known as the Engineering Building, but which had housed the department of physics for many years, and consequently possessed many conveniences and advantages which the Denver quarters lacked. A contract was negotiated between the parties, to be renewed year by year, confirming the arrangement, and the Bureau moved its equipment and personnel to Golden. At that time the School was being directed by a group of men who were actively interested in rehabilitating its lost prestige, and were hopeful that their faculty could engage in co-operative investigations with the Bureau's staff of scientists.

Unfortunately this ambition was never realized. In fact the present management of the school apparently is insensible to any advantage of the mutual association, since on June 11 they notified Superintendent S. C. Lind, that they declined to renew the contract expiring July 1 for the Engineering Building, offering instead space in the Experimental Mill, a corrugated iron building equipped as a concentrator, and obviously quite inadequate for the work being done at Golden.

Whereas it has not been definitely decided where the Colorado station will be moved, it is very probable that it will go to Reno, Nevada. The State University has offered to construct a building for such a station, and it should be as well situated as Golden for the prosecution of the special activities intrusted to it.

Properties and Constitution of Glues and Gelatines—I

A Study of Factors Influencing Viscosity and Jell Strength — Effect of Time, Mechanical Treatment, Heating and Dehydration—Influence of Concentration, Temperature and Added Substances

By ROBERT H. BOGUE, Ph.D.*

GLUES and gelatines† belong to that class of emulsoid protein-like substances which have been a Mecca for hypotheses and speculations to the colloid enthusiast, but a constant source of trouble and embarassment to the analytical chemist who encounters them. Their place among the emulsoid colloids stamps their physical properties as vague and ill-defined, and pronouncedly variable with slight alterations in the conditions under which the measurements are taken. And their protein-like nature at once assigns to them that complexity of constitution which is today, as it has always been, one of the most intricate and still unanswered problems which the chemist has set himself to solve.

A few publications[1] have appeared from time to time upon the subject in one or another of its many phases, and a few books have long been upon our shelves which have treated very briefly of the chemical and chemico-physical aspects of glues and gelatines; but, on the whole, the subject has not received a great deal of systematic attention. True, the colloid chemist has demonstrated many of his most striking colloid phenomena with gelatine, and the protein chemist has isolated many amino-acids and polypeptides from the hydrolysate of gelatine, but in both of the above cases the examination of gelatine has been merely incidental to their main problem. Manufacturers are still depending in large measure upon the "rule-of-thumb" method in production, and what advance has been made has resulted from the inevitable and costly teacher "Experience," rather than from systematic research.

This series of investigations is an attempt to correlate some of the factors upon which physical measurements depend; to systematize methods for physical and chemical examination; and to discover the relations which exist between the physical constants and the chemical constitution of glues and gelatines.

For convenience the report upon these investigations is divided into sections as follows:

A Study of Factors Influencing Viscosity and Jell Strength.

The Effect of Electrolytes Upon Degree of Dispersion; and the Structure of Gelatine Sols.

The Relation of Melting Point to Viscosity and Jell Strength.

Relations Between Physical Properties and Chemical Constitution.

Influence of Size of Molecule Upon Physical Constants.

The Physical and Chemical Significance of "Craze."

On Chemical Constitution by Determination of the Groups Characteristic of the Amino Acids.

A Study of Adhesive Properties.

Bibliography.

A STUDY OF THE FACTORS INFLUENCING VISCOSITY AND JELL STRENGTH

This section deals with a number of preliminary experiments which have as their object the determination of the effects produced upon the viscosity and jell strength of glues and gelatines by a variation in the conditions under which these measurements are taken. That these effects may be of importance has long been recognized, but the exact extent of their influence under varying conditions has not been thoroughly investigated. While no pretense is made of an exhaustion of the subject in this paper, a few of the important factors influencing viscosity and jell strength have been studied and are presented herewith. The factors considered are: time, mechanical treatment, heat treatment and dehydration, concentration, temperature, and added substances. These latter include formaldehyde, alcohols and non-electrolytes, alums, acids, bases and salts. The influence of these added substances are likewise examined under varying conditions of concentration, time, mechanical treatment, temperature and dehydration.

The results obtained are summarized at the conclusion of each section. An interpretation of the experimental findings will be considered in subsequent papers in this series of articles.

EFFECT OF TIME

The influence of time as a factor affecting the viscosity of glues was noted by running hide glues and bone

TABLE I. EFFECT OF TIME ON VISCOSITY[2]
Concentration, 30 g. glue to 150 g. water. Temperature, 60 deg. C.

Time Interval, Min.	Glue H₄	Glue B₂
0	48.6	45.0
10	48.8	44.8
20	48.8	45.2
30	49.4	46.0
40	48.6	45.6
50	48.4	45.0
60	48.8	45.2
70	48.2	45.0
80	48.0	44.4
90	48.2	45.2

[2] Grades are specified as follows: H refers to hide glues and fleshing stock. B refers to bone glues. Sub-numerals from 1 to 9 indicate relative order of the strength of their jellies, 1 being the strongest, 9 the weakest.

glues through the viscosimeter[3] at 10-min. intervals for 90 min. At the temperature at which these measurements are carried out (60 deg.), there is no appreciable change in viscosity with time. This agrees with measurements made by von Schroeder[4] and Levites,[5] who find, however, that at the low temperatures of 21 deg. and 25 deg. the viscosity increases with time.

EFFECT OF MECHANICAL TREATMENT

The effect of mechanical treatment was noted by subjecting glues to different kinds of agitation for different periods of time. Vigorous agitation in each case lowered the viscosity. This agrees with results obtained by Biltz and von Vegesack.[6]

TABLE II. EFFECT OF AGITATION ON VISCOSITY

|	Concentration, 30 g. glue to 150 g. water.			Temperature, 60 Deg.
Glue H₄	Stirred with Rod, 1 Min.	Stirred with Mechanical Beater ⅓ Min.		Stirred with Mechanical Beater 2 Min.
50.0	50.2	49.0		48.8

EFFECT OF HEAT TREATMENT AND DEHYDRATION

To determine if there were any relation between the moisture content of glues and their physical properties, glues were subjected to partial and complete dehydration by heating at 110 deg. C. for different intervals of time. The loss in moisture was noted after each heat treatment, from which was calculated its remaining moisture content, and the viscosity, jell strength,[7] solubility in cold water and solubility in hot water determined. No uniform variation in these properties could be noted until the glues had been heated for 15 hr., at which time the moisture content had fallen to zero and the resulting glues become "insoluble." The solubility of these "insoluble" glues in *cold* water was noted to be greater than before this "insoluble" state was reached. The term "insoluble" is here used to mean that condition at which the glue will no longer form a

TABLE III. EFFECT OF DEHYDRATION ON PHYSICAL PROPERTIES

Glue H₃. Sample ground and heated at 110 Deg. C.

Time Heated in Hr.	Moisture Content	Viscosity	Jell Strength	Solubility in Cold Water	Solubility in Hot Water
0	11.72	51.0	79	6.12	Soluble
1	5.87	51.4	79	6.28	Soluble
2	2.38	51.8	78	6.48	Soluble
3	1.46	52.2	79	6.59	Soluble
4	1.00	52.2	79	6.11	Soluble
5	0.50	52.0	78	6.18	Soluble
6	0.21	51.6	79	6.78	Soluble
8	0.45	51.8	78	6.49	Soluble
15	0.00	Insoluble	..	8.43	Insoluble
24	0.00	Insoluble	..	8.27	Insoluble
48	0.00	Insoluble	..	8.52	Insoluble

homogeneous emulsoid in hot water, after proper soaking in cold water.

This insoluble phase is spoken of in the literature as a reversion of the gelatin to collagen, and Hofmeister[8] considers collagen the anhydride of gelatin. He writes the equation:

$$C_{102}H_{151}O_{39}N_{31} \rightleftharpoons C_{102}H_{149}O_{38}N_{31} + H_2O$$

$$\text{Gelatin} \qquad\qquad \text{Collagen}$$
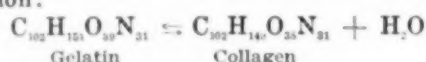
[3] The instrument used consisted of a glass tube 4 cm. in diameter and 30 cm. long, from which the liquid issued by a capillary orifice. It was standardized to pass 180 g. of water at 60 deg. C. in 42 sec. The time is noted by a stop watch, and the viscosity expressed in seconds.

[4] *Z. physik. Chem.*, vol. 45 (1903), p. 75.

[5] *Kolloid Z.*, vol. 2, (1908), p. 240.

[6] *Z. physik. Chem.*, vol. 73 (1910), p. 481.

[7] Jell strength is measured by allowing a blunt inverted cone-shaped weight to rest upon the jelly in a glass tumbler, after chilling at about 10 deg. C. The depression is measured on a graduated scale.

[8] See "Allen's Commercial Organic Analyses," 4th ed. (1912), vol. 8, p. 586.

To test this point, the insoluble phase was treated as an original ossein by soaking in lime-water for several days, and after this treatment heating for some time. A portion left in milk of lime dissolved completely, even in the cold, after ten days. A portion treated with clear lime-water remained firm. This was washed with acid and heated to 70 deg. Solution did not occur readily, but after prolonged heating most of the mass had been dissolved. This seems to be a confirmation of Hofmeister's conclusions.

The effect of prolonged heating on a solution of gelatine was found by Amon,[9] von Schroeder[10] and Levites[11] to produce a marked decrease in viscosity.

INFLUENCE OF CONCENTRATION

The influence of concentration on the viscosity and jell strength was shown by running the entire list of standard glues through the viscosimeter at four different concentrations, and allowing these solutions to set for jell strength measurements. In all cases the viscosity increases with the concentration, slowly at the lower concentrations but very rapidly at the higher values.

TABLE IV. EFFECT OF CONCENTRATION ON VISCOSITY AND JELL STRENGTH

	Viscosity											
Ratio of Glue to Water	Hide Glues						Bone Glues					
	H₁	H₂	H₃	H₄	H₅	H₆	B₁	B₂	B₃	B₄	P₅	P₆	B₉
10/170	42.0	42.4	42.6	42.0	41.8	41.4	40.8	41.8	42.0	41.0	42.0	41.8	41.4
20/160	46.4	46.4	44.2	43.8	42.6	42.6	43.0	44.0	42.8	42.4	42.4	41.4	41.4
30/150	59.8	58.4	49.4	49.0	47.0	47.0	48.4	50.6	53.2	44.6	43.8	42.4	41.6
40/140	99.8	83.6	60.0	63.2	56.4	57.8	59.8	61.4	52.8	50.0	47.6	46.2	43.4

	Jell Strength											
10/170	70	65	60	57	58	48	56	42	40	33	23	22	liquid
20/160	79	78	75	74	73	71	75	69	65	58	55	52	liquid
30/150	83	80	78	77	76	75	80	76	74	65	62	60	liquid
40/140	89	86	82	79	78	77	83	78	77	72	67	64	53

INFLUENCE OF TEMPERATURE

The influence of temperature on the viscosity was shown by running glues at 5 deg. temperature intervals between 30 and 75 deg. The results show a regular increase in viscosity with decrease in temperature. The graph does not, however, show a straight line, for the viscosity increases slowly at high temperature and becomes rapid as the temperature falls toward the jelling point of the glue.

TABLE V. INFLUENCE OF TEMPERATURE ON VISCOSITY

Temperature, Deg. C.	Viscosity in Order of Decreasing Temperature 1, H₄	Viscosity in Order of Increasing Temperature 1, H₄	Viscosity 2, H₄	..ty 3, B₂
75	47.6	....	....	....
70	47.6	47.2	47.6	42.6
65	48.2	48.2	47.0	43.0
60	48.8	48.6	47.8	43.2
55	49.6	48.8	49.6	43.8
50	50.6	50.2	50.4	44.0
45	50.8	51.4	53.2	44.8
40	51.8	53.6	56.2	45.2
35	53.8	56.6	....	46.0
30	60.0	....	70.6	47.6

INFLUENCE OF ADDED SUBSTANCES
VARYING CONCENTRATION OF FORMALDEHYDE

Runs for viscosity were made with the entire set of standard glues to which were added amounts of formaldehyde varying from 0.8 to 40.0 c.c. of 10.0 per cent solution. This entire series was repeated four times,

[9] Unpublished investigation conducted at Mellon Institute.

[10] *Z. physik. Chem.*, vol. 45, (1903), p. 75.

[11] *Kolloid Z.*, vol. 2 (1908), p. 240.

with varying concentrations of glue; e.g., 10, 20, 30 and 40 g. of glue to 180 g. total weight of solution.

The results may be summarized as follows:

The viscosity varies directly as the amount of formaldehyde added.

After the addition of a certain amount of formaldehyde, the glue sets rather suddenly to a jelly which may not again be brought into solution by the usual means.

The transitional stages between the time when a glue shows only a moderate viscosity and when its viscosity has become too high to measure in the tube may be very short, especially in the weaker concentrations; so short that even in the time it takes to make the test the glue may have changed from a solution of watery consistency to a jelly.

The effect of formaldehyde on viscosity varies very considerably with the different grades of glue, much

FIG. 1. THE EFFECT OF FORMALDEHYDE ON VISCOSITY

smaller amounts of formaldehyde being required to produce marked changes in viscosity and insolubility in the higher than in the lower grades of glue.

In the case of the weaker concentrations, a slight but persistent drop in viscosity is noted following the addition of the first few c.c. of formaldehyde.

The data obtained from glue H_4, which is typical of the series, are given in Table VI and are expressed graphically in Fig. 1.

TABLE VI. EFFECT OF FORMALDEHYDE ON VISCOSITY. GLUE H_4.
TEMPERATURE 60 DEG.

Ratio of Glue to Water: C.c. of 10 per Cent HCHO Added	10/170	20/160	30/150	40/140
0.0	42.0	43.8	49.0	63.2
0.8	....	....	50.2	70.8
1.2	....	....	53.0	77.6
1.6	....	....	54.2	93.6
2.0	....	44.4	55.0	Set
3.0	42.0	45.2	61.8	....
5.0	42.0	47.6	Set	....
7.0	....	Set	....	....
10.0	43.2	....	....	....
20.0	43.2	....	....	....
40.0	43.6	....	....	....

The effect of formaldehyde on the jell strength was noted by allowing solutions of all grades of glue in four different concentrations, and containing formalde-

hyde as above, to chill at 35 to 40 deg. F. and jell strength observed.

In the higher concentration of glue, the formaldehyde induced the formation of a hard crust on the surface, often harshly wrinkled, which rendered the readings on such samples quite valueless. In the lower concentrations, however, this effect was not pronounced, and the readings are reliable. The results may be summarized as follows:

The jell strength diminishes regularly as the amount of formaldehyde added increases.

This decrease in jell strength is most marked in the weaker glues, which often would not jell at all after the addition of but a few c.c. of formaldehyde.

The results of formaldehyde treatment on the jell strength of Glue H_4 are expressed graphically in Fig. 2.

TABLE VII. EFFECT OF FORMALDEHYDE ON JELL STRENGTH
GLUE H_4

Ratio of Glue to Water: C.c. of 10 per cent HCHO Added	10/170	20/160	30/150	40/140
0.0	57	75	80	84
0.8	..	..	79	79
1.2	..	..	78	80
1.6	..	..	78	79
2.0	..	69	77	....
3.0	54	70	72	69
5.0	50	..	69	64
7.0	..	..	66	70
10.0	42	60	64	68
20.0	38	..	..	....
40.0	31	..	..	....

The "formaldehyde capacity" of all of the standard glues at working concentrations was also determined. By "formaldehyde capacity" is meant the maximum amount of formaldehyde which a glue at that concentration may contain without producing insolubility. The
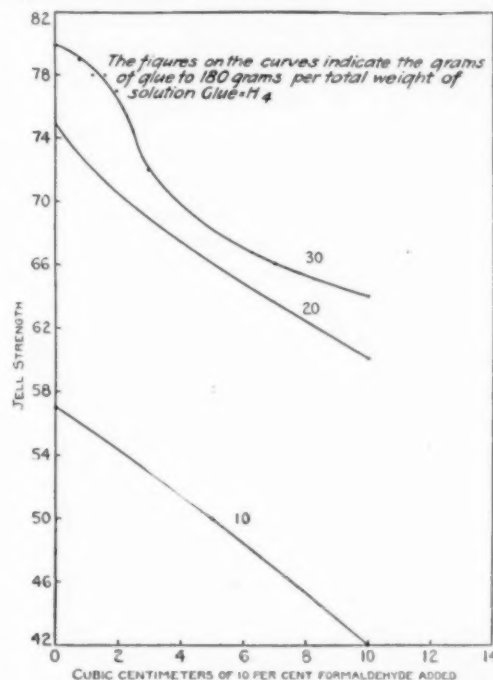
FIG. 2. THE EFFECT OF FORMALDEHYDE ON JELL STRENGTH

glues were made up in concentrations of from 1 to 2½ up to 1 to 1 and small amounts of formaldehyde added. These were then watched constantly for 2 hr., and the time required to produce insolubility noted.

The general tendency toward a greater formaldehyde capacity in the weaker glues is clearly evident from the data obtained and shown in Table VIII, and expressed graphically in Fig. 3. This formaldehyde capacity is

TABLE VIII. SETTING PERIODS OF FORMALDEHYDE GLUES AT HIGH CONCENTRATIONS

Figures given in minutes to set. Maximum observation, 2 hr. Temperature 60 Deg. Weight solution, 180 g.

Grade	Glue Concentration	Wt. Glue	1.0	1.5	2.0	2.5	3.0	4.0	7.0
H_1	1 to 2½	51.4	60	..	15	..	..	..	..
H_2	1 to 2½	51.4	150	..	15	..	..	..	..
H_3	1 to 2½	51.4	..	50	15	..	..	..	..
H_3	1 to 2	60	60	..	15	..	..	..	..
H_4	1 to 2	60	150	..	15	..	..	..	..
H_5	1 to 2	60	..	60	15	..	..	..	..
H_6	1 to 2	60	..	..	..	30	..	..	..
H_6	1 to 1½	72	..	..	25	..	..	..	..
B_1	1 to 2	60	..	..	.60	..	..	..	..
B_2	1 to 2	60	..	..	60	..	..	..	..
B_3	1 to 2	60	..	..	..	..	25	..	..
B_3	1 to 1½	72	..	..	35	..	..	..	..
B_4	1 to 1½	72	..	..	90	..	..	..	..
B_5	1 to 1½	72	..	..	..	..	20	..	..
B_6	1 to 1½	72	..	..	..	..	..	25	..
B_8	1 to 1	90	..	..	35	..	..	..	..
B_9	1 to 1	90	..	..	..	..	..	..	90

undoubtedly a function of the chemical composition, the amount of formaldehyde required for precipitation being inversely proportional to, for example, the protein present in the glue.

VARYING CONCENTRATION OF GLUE

The effect of varying the concentration of the glue may readily be observed by selecting a given amount of fosmaldehyde to be added and noting the effect of this amount on varying concentrations of glue. When this is done, it will be observed that the effect of the formaldehyde becomes felt at much lower concentrations in the high-grade glues than in the low-grade glues.

TABLE IX. EFFECT OF FORMALDEHYDE ON VISCOSITY

Temperature, 60 Deg. C. Weight solution, 180 g. Formaldehyde added, 3 c.c. 10 per cent solution

Weight Glue	H_1	H_2	H_3	H_4	H_5	H_6	B_1	B_2	P_3	B_4	P_5	P_6	P_9
10	41.8	41.6	43.4	42.0	42.0	41.0	40.4	41.0	41.8	41.0	41.8	41.8	41.4
20	48.8	51.2	45.0	45.2	44.2	43.0	44.0	44.2	42.8	42.2	42.6	41.4	41.6
30	Set	Set	54.8*	61.8*	63.4*	57.0	56.4	52.4	47.6	45.8	45.0	43.6	42.0
40	Set	Set	Set	Set	Set	80.2*	75.0*	80.0*	60.8	58.6	50.0	49.0	44.0

* Indicates that the glue set shortly after viscosity was taken.

Showing the amount of 10 per cent formaldehyde required to produce insolubility in the various glues at specific concentrations. The figures on the curves indicate the grams of glue to 180 grams per total weight of solution
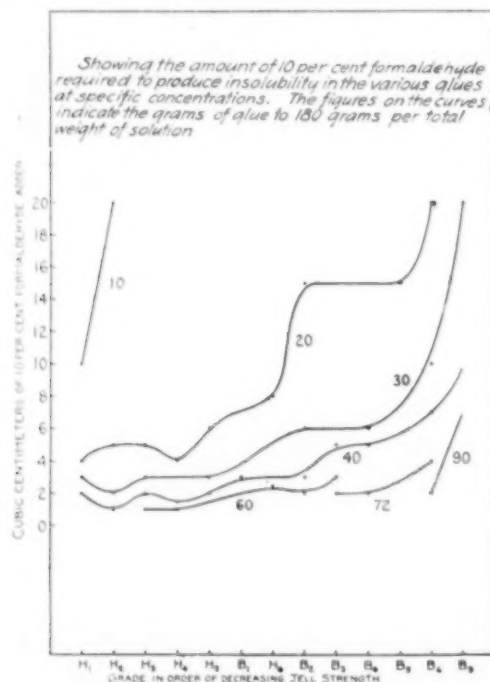
FIG. 3. INSOLUBILITY CURVES

1-GLUE H_4 - 4 cc HCHO
2-GLUE B_3 - 10 cc HCHO
3-GLUE H_4 - 3 cc HCHO
4-GLUE B_3 - 7 cc HCHO
5-GLUE B_3 - 5 cc HCHO
6-GLUE H_4 - UNTREATED
7-GLUE B_3 - UNTREATED
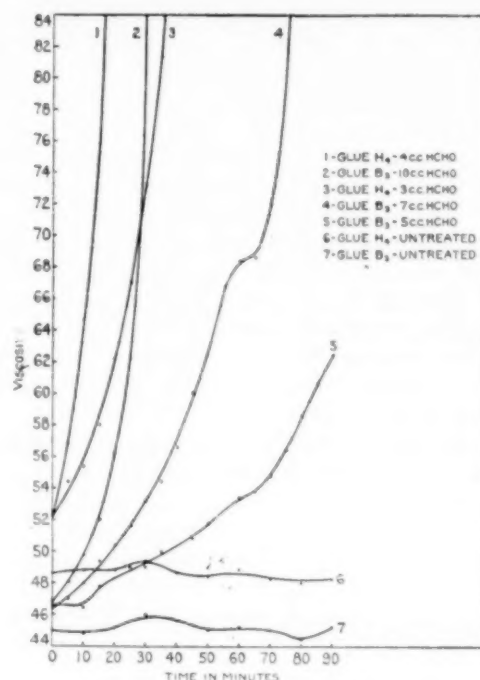
FIG. 4. THE EFFECT OF TIME UPON THE VISCOSITY OF FORMALDEHYDE-TREATED GLUES

INFLUENCE OF TIME

The influence of time on the effect of formaldehyde on glue was shown by treating two glues with varying amounts of formaldehyde and noting the viscosity at 5-min. intervals for 90 min., or until set. The results show viscosities increasing with time, slowly at first,

TABLE X. EFFECT OF TIME ON VISCOSITY OF FORMALDEHYDE GLUES

Concentration, 30 g. glue to 180 g. total weight. Temperature, 60 deg. C.

C.c. 10 per Cent HCHO Temperature Interval in. Min.	Glue H_4			Glue B_3			
	0	3	4	0	5	7	10
0	48.6	52.2	52.2	45.0	46.6	46.4	46.8
5	....	54.4	56.8	....	46.6	47.0	48.0
10	48.8	55.4	64.6	44.8	46.4	48.0	49.8
15	....	58.0	75.8	....	47.8	49.4	52.0
20	48.8	62.2	93.4	45.2	50.6	50.4	56.2
25	....	67.0	Set	....	49.0	51.6	62.2
30	49.4	73.2	....	46.0	49.0	53.2	83.6
35	....	81.4	....	....	50.0	54.4	Set
40	48.6	99.6	....	45.6	50.4	56.6	....
45	....	Set	....	....	50.8	60.0	....
50	48.4	....	....	45.0	51.8	63.0	....
55	....	....	....	....	52.6	66.6	....
60	48.8	....	....	45.2	53.4	68.4	....
65	....	....	....	....	53.8	68.6	....
70	48.2	....	....	45.0	54.8	72.0	....
75	....	....	....	....	56.4	100.0	....
80	48.0	....	....	44.4	58.6	Set	....
85	....	....	....	....	60.6	....	....
90	48.2	....	....	45.2	62.4	....	....

but becoming very rapid as the point of setting is approached. The rate of increase is much greater in the high-grade than in the low-grade glues, and much more rapid with the higher than with the lower concentrations of formaldehyde.

These results are expressed graphically in Fig. 4.

INFLUENCE OF MECHANICAL TREATMENT

The effect of agitation on the viscosity of formaldehyde-treated glues was noted by subjecting glues to which varying amounts of formaldehyde had been added, to different kinds of agitation and noting its effect on the viscosity.

Although the actual viscosity after the treatment was greater in most instances than before treatment, yet, when this increase is compared to the increase noted in a glue treated similarly with formaldehyde but not agitated, it is found to be less than normal. This lessening in the rate of increase is, however, no greater than the actual decrease observed in an untreated glue on similar agitation. It is concluded, therefore, that the effect of agitation on the viscosity of a formaldehyde glue is relatively to decrease it, although the increase due to the time factor is so great as to reverse the actual readings, an actual increase being observed.

INFLUENCE OF TEMPERATURE

The influence of temperature on the viscosity of formaldehyde glues was shown by treating glues with varying amounts of formaldehyde, after the desired

TABLE XI. EFFECT OF AGITATION ON VISCOSITY OF FORMALDEHYDE GLUES

Concentration, 30 g. glue to 180 g. total. Temperature, 60 deg. C.

	Glue H_4				Glue B_3	
C.c. of 10 per Cent HCHO added:	0	2	3	4	7	10
Viscosity, no agitation.....	50.0	50.6	51.6	53.8	46.6	48.0
Stirred one minute........	50.2	51.2	53.6	56.4	....	....
Beaten one-half minute....	49.0	52.0	55.4	60.2	....	....
Beaten two minutes.......	48.8	52.2	58.0	74.0	45.0	48.6

temperature has been reached, allowing to stand at that temperature for 15 min., and then taking the viscosity. The time factor is thus entirely eliminated.

A study of the results shows in all cases first a drop in viscosity with rise of temperature. When the curves

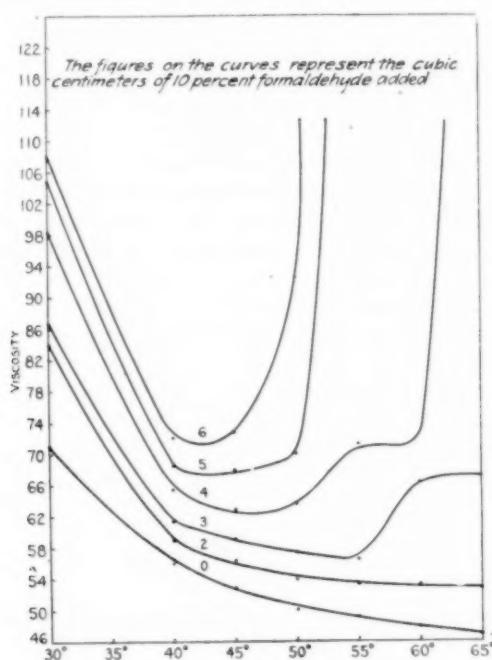FIG. 5. THE EFFECT OF TEMPERATURE UPON THE VISCOSITY OF FORMALDEHYDE-TREATED GLUE

are plotted in such a way as to eliminate the influence of the temperature on the untreated glue, it will be seen that the formaldehyde has the least effect at a temperature of 40 deg. C. Below and above this temperature the effect is very pronounced. The effect of a few degrees variation in temperature becomes more and more decided as the amount of formaldehyde is increased, and the range through which the resulting mixture remains mobile is considerably narrowed. It is evident that if it is desired to work a high formaldehyde

glue the optimum temperature of 40 deg. should be selected.

TABLE XII. INFLUENCE OF TEMPERATURE ON VISCOSITY OF FORMALDEHYDE GLUES

Glue H_4. Concentration, 30 g., glue to 180 g. total weight. Time, 15 min.

C.c. of 10 per Cent HCHO Added: Temperature, Deg. C.	0	2	3	4	5	6
30	70.6	83.8	86.6	98.2	104.8	108.6
40	56.2	58.8	61.6	65.2	68.6	72.0
45	53.2	56.4	58.8	62.8	68.0	72.8
50	50.4	53.8	57.4	63.8	70.2	92.4
55	49.6	53.4	56.8	71.2	135.4	Set
60	47.8	53.4	66.4	71.0	Set	Set
65	47.0	53.0	67.0	Set	....	....
70	47.6	55.2	88.8	Set	....	....

These results are expressed graphically in Fig. 5.

EFFECT OF DRYING ON VISCOSITY AND SOLUBILITY

To determine the permanent effect which formaldehyde might have on a glue, the glue H_4 was treated in two concentrations with varying amounts of formaldehyde. The viscosity was taken after 15 min., the glues then dried and, after drying, were again brought into solution, if possible, and the viscosity taken.

It is seen that the viscosity of the samples after treatment is greater in all cases than that of the original solutions. This increase is proportional to the volume of the formaldehyde used and to the concentration of

TABLE XIII. EFFECT OF DRYING ON VISCOSITY AND SOLUBILITY OF FORMALDEHYDE GLUES

Glue H_4. Temperature, 60 Deg. C. Time, 15 Min.

C.c. of 10 per Cent HCHO Added:	30 g. Glue to 180 g. Total Weight					40 g. Glue to 180 g. Total Weight	
	0	1	2	3	4	0	1
Viscosity after 15 min...	48.8	51.0	43.4	66.4	71.0	63.2	75.8
Viscosity after drying...	49.0	53.2	56.0	75.2	Insol.	63.0	Insol.

the glue. It seems probable that the mere physical process of drying alone has no influence on the viscosity, but rather that the change noted is a function of the time factor alone.

ALCOHOLS AND NON-ELECTROLYTES

The influence of three alcohols on viscosity was tested. Methyl, ethyl and amyl alcohols were added to glues H_2, H_5 and B_4 and allowed to act for 15 and 90 min. after which time intervals the viscosities were taken.

In all cases the viscosity is increased above that of the untreated samples. This increase diminishes, however, with time. An excess of the methyl and ethyl alcohols produces insolubility by precipitation of the proteins. These were not precipitated by the amyl alcohol, but a persistent white crust as of a crystallizing salt formed on the surface.

TABLE XIV. EFFECT OF ALCOHOLS ON VISCOSITY

Concentration, 30 g. glue to 180 g. total weight. Temperature, 60 deg. C.

	Glue H_2		Glue H_5		Glue B_4	
	15 Min.	90 Min.	15 Min.	90 Min.	15 Min.	90 Min.
Distilled water........	55.2	....	47.6		45.2	
10 c.c. methyl alcohol..	57.4	55.4	49.4	48.2	45.8	45.8
10 c.c. ethyl alcohol...	60.6	56.0	50.0	49.0	47.0	45.8
10 c.c. amyl alcohol...	58.4	56.6	50.8	49.6	47.4	46.6

The influence of chloral hydrate on viscosity and jell strength was studied. This substance was added to glues H_2 and H_3 in amounts varying from 1.0 to 30.0 per cent. Its influence was very marked. It was found to increase the viscosity very considerably and to lower the jell strength until the mixture would no longer jell

at 5 deg. C. The increase in viscosity was found to continue regularly even after such concentrations had been added that the solution would not jell.

TABLE XV. INFLUENCE OF CHLORAL HYDRATE ON VISCOSITY AND JELL STRENGTH

Concentration, 30 g. glue to 180 g. total weight. Temperature, 60 deg. C.

Amount added, g...	0	1.8	3.6	9.0	10.8	18.0	27.0	36.0	54.0
Equivalent to per cent.............	0	1	2	5	6	10	15	20	30
Glue H₁, viscosity..	49.8	49.8	49.6	50.6	....	52.2			
Glue H₂, viscosity..	54.2	....	55.4	....	56.0	56.8	60.0	64.6	75.2
Glue H₁, jell.......	83.0	84.0	83.0	82.0	....	77.0			
Glue H₂, jell.......	84.0	....	84.0	....	83.0	81.0	76.0	66.0 liquid	

These results are plotted in Figs. 9 and 10.

ALUMS
INFLUENCE OF CONCENTRATION

Aluminum, chromium and iron potassium alums were made up in tenth normal solutions and added to several
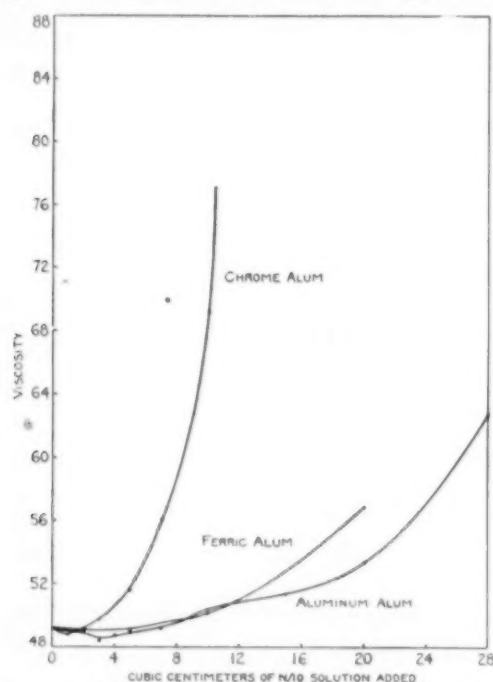

FIG. 6. THE EFFECT OF ALUMS ON VISCOSITY

glues in amounts varying between 1 and 50 c.c., and the viscosities taken after standing for 15 min. at 60 deg. C.

The iron alum formed minute droplets on contact with the glue unless greatly diluted, and a satisfactory

TABLE XVI. EFFECT OF ALUMS ON VISCOSITY AND JELL STRENGTH

Glue H₄. Concentration, 30 g. glue to 180 g. total weight. Temperature, 60 deg. C.; time, 15 min.

C.c. N/10 Solution	Al Viscosity	Al Jell	Cr Viscosity	Cr Jell	Fe Viscosity	Fe Jell
0	49.2	78	49.2	78	49.2	78
1	49.0	78	48.8	78	....	..
2	49.0	79	....	..	....	..
3	48.4	80	49.8	80	....	..
4	48.8	79	....	..	....	..
5	....	..	51.6	79	49.0	81
7	49.2	..	56.0	78	....	..
10	50.4	78	69.2	76	50.2	81
15	51.4	82	Set	75	....	..
20	53.4	80	....	..	56.8	79
30	64.6	77	....	..	....	..
40	84.0	77	....	..	....	..
50	Set	76	....	..	....	..

solution could not be effected with larger amounts than 20 c.c.

The alums all produced increases in viscosity much

the same as the formaldehyde had done except that a much larger amount of the former had to be added in order to obtain the same degree of increase. The chrome alum showed much the greatest effect of the three, producing insolubility when only 15 c.c. had been added, as against 50 c.c. of the aluminum alum.

The influence of these substances on the jell strength does not seem to be appreciable.

These results are expressed graphically in Fig. 6.

INFLUENCE OF TIME AND OF TEMPERATURE

The influence of time on the viscosity of alum glues was noted by adding different amounts of the alums to the glues, and measuring the viscosity at intervals up to 80 min.

The data reveal the fact that the influence of time on the viscosity of alum glues is exactly opposite to its influence on formaldehyde glues. Whereas with the latter the viscosity rapidly increases from a condition of watery consistency to its setting point, the alum glues, on the other hand, develop their maximum viscosity very quickly, after which, however, it rapidly decreases with time to a low value, approaching that of the untreated glue.

TABLE XVII. EFFECT OF TIME ON VISCOSITY OF ALUM GLUES

Glue H₄. Concentration, 30 g. glue to 180 g. total weight. Temperature 60 Deg. C.

Time Interval in Min.	0 c.c.	Al (N/10) 20 c.c.	Al (N/10) 40 c.c.	Cr (N/10) 10 c.c.	Cr (N/10) 12 c.c.
1	49.2	56.4	Set	66.4	135.0
2	....	....	280.0	....	144.2
4	....	....	....	68.4	Set
6	....	54.8	175.0	....	Set
8	....	....	....	66.6	Set
10	....	53.4	130.0	64.4	144.6
20	....	51.8	80.6	60.4	89.6
30	....	51.4	78.0	60.6	85.2
40	....	51.4	73.4	58.6	80.4
50	....	51.6	69.4	57.8	79.4
60	....	49.8	61.4	57.2	74.2
70	....	49.8	61.6	55.6	72.4
80	....	50.0	61.6	56.2	73.0

These results are expressed graphically in Fig. 7.

The influence of temperature on the viscosity of alum glues was noted by treating glues with different amounts of alum solutions, after heating to the desired temperature, and allowing to stand at that temperature for
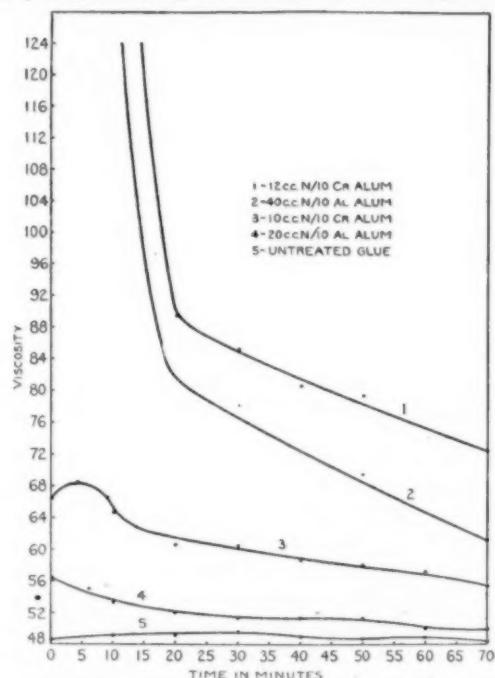

FIG. 7. THE EFFECT OF TIME UPON THE VISCOSITY OF ALUM-TREATED GLUES

15 min. The viscosities were then taken. Temperature intervals of 10 deg. were used between 30 and 70 deg. C.

The data show the effect of varying temperature on the viscosity of alum glues to be likewise different from its effect on formaldehyde glues. Between 30 and 40 deg. the effect is the same, e.g., a lowering in viscosity, but above 40 deg. the alum glues continue
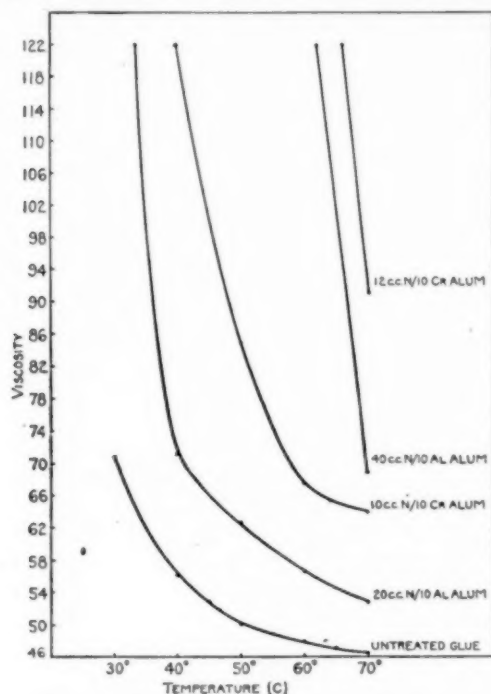

FIG. 8. THE EFFECT OF TEMPERATURE UPON THE VISCOSITY OF ALUM-TREATED GLUES

regularly to decrease in viscosity, whereas in the formaldehyde glues it rises rapidly from that temperature.

From the above experiments, it would seem that although both alums and formaldehyde may produce insolubility in glues and increase their viscosity in proportion to the amount used, yet, inasmuch as the effects of time and temperature are so different in the two cases, the physical or chemical mechanism of the processes is undoubtedly quite different.

TABLE XVIII. INFLUENCE OF TEMPERATURE ON VISCOSITY OF ALUM GLUES

Glue H4. Concentration, 30 g. glue to 180 g. total weight. Time, 15 min.

Temperature, Deg. C.	Al (N/10) 20 c.c.	Al (N/10) 40 c.c.	Cr (N/10) 10 c.c.	Cr (N/10) 12 c.c.
30	260.0	Set	Set	Set
40	70.8	Set	123.0	Set
50	62.4	400.0	85.0	Set
60	56.4	143.0	67.4	Set
70	53.0	69.2	60.0	91.2

These results are expressed graphically in Fig. 8.

ACIDS, BASES AND SALTS

The influence of acids, bases and salts on viscosity and jell strength has been tested in a number of ways. Several salts, acids and bases were added to nine different glues in varying concentrations from 0.1 to 30.0 per cent and the viscosities and jell strengths noted.

The results obtained may be summarized as follows:

Practically all of the substances added lowered the jell strength.

Strong (9N) sodium hydrate had the greatest effect, followed by potassium iodide, strong (9N) sulphuric acid, sodium sulphate, acetic acid and magnesium chloride. The effect of the others was small.

The viscosity was raised constantly by magnesium chloride, chloral hydrate and sodium silicate.

The viscosity was raised to a maximum, after which it fell more or less rapidly by sodium hydrate, disodium phosphate and acetic acid.

The viscosity was lowered constantly by potassium iodide, sulphuric acid, phosphoric acid and sodium sulphate.

There was no appreciable effect on the viscosity due to sodium chloride and magnesium sulphate.

Monosodium phosphate produced a sharp drop of one second at 0.1 per cent, followed by a sharp rise of $3\frac{1}{2}$ sec. at 0.5 per cent, after which it rose a little further and then dropped again.

A part of the data for glue AA which is typical of the whole series is given in Table XIX, and is expressed graphically in Figs. 9 and 10.

TABLE XIX. EFFECT OF ELECTROLYTES ON VISCOSITY AND JELL STRENGTH GLUE H_2.

Concentration, 30 g. glue to 180 g. total weight.

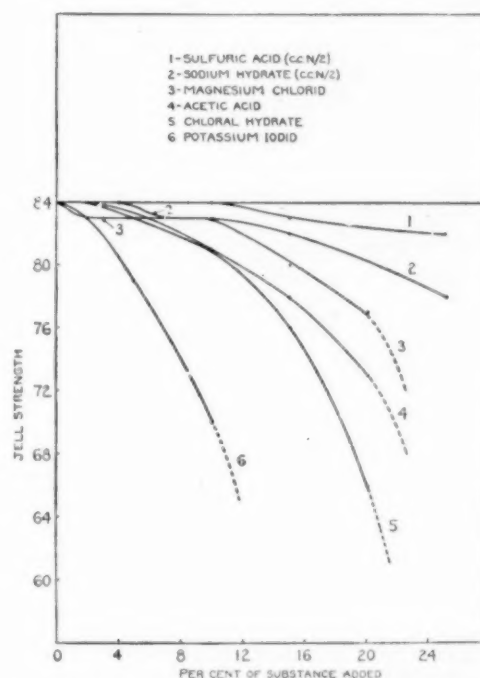|	Per Cent added	KI	CH_3COOH	$MgCl_2$	H_3PO_4	NaH_2PO_4	Na_2HPO_4	H_2SO_4 c.c.N/2	NaOH c.c.N/2
Viscosity	0.0	54.2	54.2	54.2	54.2	54.2	54.2	54.2	54.2
	0.1	54.2	....	....	53.4	53.2	54.2	....	....
	0.5	54.0	....	....	52.6	56.8	54.8	....	....
	1.0	53.8	....	....	51.4	58.0	57.6	54.8	54.4
	2.0	53.4	53.6	54.6	49.4	57.4	60.2	....	....
	5.0	....	....	....	47.2	57.2	58.2	53.6	54.0
	7.0	....	54.6	57.2	....	....	....	53.0	55.0
	10.0	....	55.4	59.0	45.4	58.4	57.0	52.6	55.4
	15.0	....	56.4	62.2	....	....	....	52.8	55.8
	20.0	52.6	58.8	67.2	....	....	....	51.4	59.0
	25.0	....	....	....	....	....	....	....	....
	30.0	48.0	48.2	71.0					
Jell Strength	0.0	84	84	84	84	84	84	84	84
	0.1	84	..	..	84	83	84	..	..
	0.5	..	..	..	83	83	84	..	..
	1.0	84	..	..	84	83	83	84	84
	2.0	83	84	83	84	83	81	..	..
	5.0	79	..	..	83	83	83	..	..
	7.0	..	83	83	..	..	..	..	..
	10.0	70	81	83	81	82	84	84	83
	15.0	..	78	80	..	..	..	83	82
	20.0	liq.	73	77	..	..	..	82	78
	25.0	..	..	..	..	..	..	..	..
	30.0	..	liq.	liq.	..	..	..		

FIG. 9. THE EFFECT OF ADDED SUBSTANCES UPON JELL STRENGTH

The experimental findings which have been presented in this chapter may be briefly summarized as follows:

There is no variation in the viscosity of normal glues with time up to 90 min.

Vigorous agitation of a glue or gelatine results in a lowering of the viscosity.

Prolonged heating results in a decrease in viscosity.

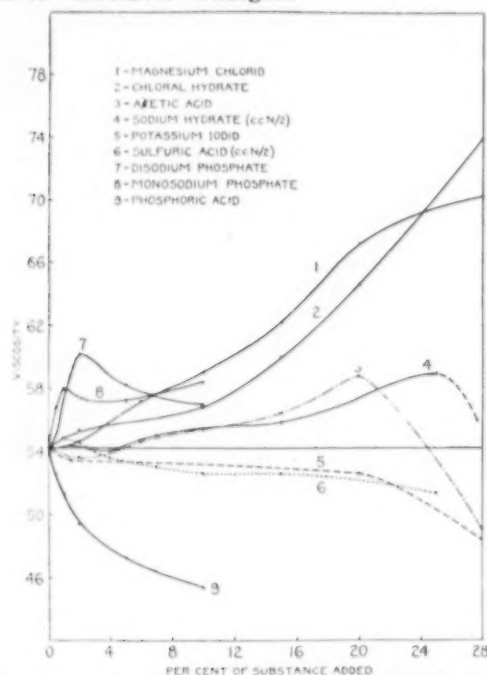Dehydration produces a reversion of "soluble" gelatine to "insoluble" collagen.

FIG. 10. THE EFFECT OF ADDED SUBSTANCES UPON VISCOSITY

At temperatures well above the melting point the viscosity increases nearly as a logarithmic function of the concentration.

The viscosity varies inversely as the temperature.

The viscosity varies directly as the amount of formaldehyde added. The higher the grade of a glue, and the higher the concentration, the less the amount of formaldehyde required to produce "insolubility."

The jell strength varies inversely as the amount of formaldehyde added. This effect is the more marked in the weaker grades of glue, and in the lower concentrations.

The viscosity of formaldehyde-treated glues increases with the time.

The viscosity of formaldehyde-treated glues decreases with rise in temperature up to about 40 deg. C. Above this temperature the viscosity rapidly increases to the setting point.

The addition of chloral hydrate results in a continually increasing viscosity, and a continually decreasing jell strength.

Alums produce increasing viscosities, but have little or no effect upon jell strength.

The viscosity of alum-treated glues increases very rapidly with time for a few minutes, after which maximum it decreases slowly.

The viscosity of alum-treated glues decreases regularly with rise in temperature.

Nearly all electrolytes produce a lowering in the jell strength, but their effect upon viscosity may be continually to increase, continually to decrease, or first to increase and later to decrease the viscosity.

(Part II will appear in a subsequent issue.)

Utilization of British Water Powers

The report of the British Government Water Power Resources Committee (which will shortly be published) sets forth a scheme for the utilization of the water power of the United Kingdom in place of coal and oil. The committee's task was to consider the extent to which the water power in rivers can be made available as power for industry, and to advise on the steps to be taken to insure that the water resources are properly conserved and fully utilized for all purposes.

The chief recommendation is the creation of a body of water commissioners as a department of the Board of Trade, with general authority to see that the water power in the country is utilized to the best advantage. These commissioners would have functions similar to the electricity commissioners already appointed, and would be able to approve local schemes for the development of the water supply without the reference to Parliament now necessary. They would also encourage the promotion of local schemes and prevent wasteful competition between local authorities for water supplies.

An important recommendation of the forthcoming report is that where one authority has more water than it requires it should be compelled to supply it to a less favored district at a reasonable cost. The committee has mapped out the whole of England and Wales into districts as they are served by different watersheds, and suggests the creation of local committees in counties and groups of counties to arrange for the best use of the water supply in those districts.

Market for American Dyes in Burma

The few consignments of American dyes that have arrived in Burma are reported so satisfactory in quality that importers have signified their desire to receive more, especially of those adapted to dyeing silks, as the supplies of the native cotton-dyeing works are obtained from India. The colors most in demand are pink (three shades), green, blue, first red, scarlet, orange, lemon, yellow, violet, black, and blue-black. Dyes for this market should be put up in 1-oz., 7-oz. and 1-lb. tins, wrapped in labels showing the color, and packed in tin- or zinc-lined cases, as the usual paper wrappings are worthless in this climate. The smaller sized tins have the readier sale. Aniline dyes pay an import duty of $7\frac{1}{2}$ per cent ad valorem upon the fixed tariff valuation of 2 rupees per pound moist, and four rupees per pound dry.

Alberta May Resume Sugar-Beet Raising

The present high price and scarcity of cane sugar have led J. A. Grant, British Columbia Fruit Commissioner, with headquarters in Calgary, Alta., to declare that resumption of sugar beet growing is necessary to prevent extreme shortage.

Sugar beets were formerly grown successfully in Alberta and a factory was operated at Raymond, but at that time competition with cane sugar, which sold at 8c. and 10c. per lb. was too keen and the industry was abandoned.

At the present price of cane sugar, it is estimated that beet sugar can be produced at a profit in competition with it, and already commercial interests are seriously considering entering this field. Mr. Grant is quoted as saying that beet sugar can be produced in Alberta at 10c. a lb.

The Heat Treatment of a High-Chromium Steel

A Study of the Relation of Various Heat Treatments on the Physical Properties and Microscopic Appearance of Stainless Steel — Comparatively High-Temperature Annealing Is Required to Alter the Structure of the Hardened Material

BY H. J. FRENCH* AND YOSHITO YAMAUCHI†

HIGH-CHROMIUM steel containing about 11 to 15 per cent of chromium and usually 0.20 to 0.40 per cent of carbon is manufactured under the name of "Stainless Steel," because of its peculiar property, when properly hardened and finished, of resisting oxidation and corrosion by the ordinary agents.

Originally employed in the manufacture of cutlery, such steel has proved its value in other fields and gives promise of wider application. It has been successfully used to replace high-nickel and high-speed steels for valves in airplane and automobile engines and will probably receive attention for other machine parts subjected to corrosive action or oxidizing service conditions.

One of its main disadvantages is its high chromium content, which makes it a costly alloy. It is also quite sensitive to mechanical and thermal treatments, but combines high strength and good ductility with its ability to resist corrosion, which is a combination difficult to duplicate.

While chromium was one of the first of the steel-alloying elements, its use was for many years confined to high-carbon products due to the difficulty of manufacturing carbon-free chromium. So-called "Stainless Steel" is, therefore, one of the indirect results of improvements in the manufacture of carbon-free ferro-alloys.

PREVIOUS INVESTIGATIONS

Comparatively little information has been published concerning the physical properties of "Stainless Steel." In 1917, W. H. Hatfield[1] published results of tensile and impact tests of a steel containing 0.30 per cent carbon and 13.0 per cent chromium. A comparison between air, oil and water quenching followed by relatively high temperature tempering is given. His tensile test results have also been incorporated in the tentative report of the Iron and Steel Committee of the Society of Automotive Engineers[2] and constitute the major portion of the physical test data there given. The latter report, however, includes a valuable and interesting discussion of the proper methods of working, annealing and finishing such steel and a comparison between stainless, high-speed and some commonly used structural alloy steels, in resistance to oxidation at high temperatures.

A rather complete discussion of the properties of stainless steel is given by Seidell and Horvitz in *Iron Age*.[3] The work of previous investigators on high-chromium steels of varying carbon content is reviewed, and typical differential heating and cooling curves are

given for a steel containing 0.33 per cent carbon and 11.02 per cent chromium. The authors clearly show the suppression of the ferrite transformation together with the lowering of the A_1 transformation as maximum heating temperature is increased. Brinell hardness values under varying quenching and temperature treatments and relation to so-called "red-hardness" are also shown. Little data are given, however, on the tensile properties.

MATERIAL USED

In order to determine the effect of various heat treatments on the tensile properties of such high-chromium steel and throw further light on its possible use for various machine parts, a series of tests has been carried out on two bars of annealed 1-in. hot-rolled rounds of the following composition:

	Ladle Per Cent.	Checks Per Cent.
Carbon	0.27	0.29 (0.24)
Manganese	.52	.38 (0.36)
Phosphorus	.011	.009
Sulphur	.009	.015
Silicon	.695	.70
Chromium	12.4	13.2 (13.2)

In the annealed condition, as supplied, the steel showed the following tensile properties, in which condition it machines quite readily:

Proportional limit, lb. per sq. in.	64,000
Tensile strength, lb. per sq. in.	106,900
Elongation in 2 in., per cent	26.0
Reduction in area, per cent	58.5
Brinell hardness number	222
Shore hardness number	34

METHODS USED

All treatments were carried out on standard Zimmerscheid tensile test specimens, the gage length being left 3/32 in. larger than the specified diameter (0.505 in.) for grinding after heat treatment. The effective diameter in treatment was, therefore, 11/16 in. For hardening, samples were heated in gas-fired furnaces, while for tempering, an oil bath was used at 400 deg. F. (205 deg. C.), a 2 to 1 mixture of sodium and potassium nitrates at 800 and 1,000 deg. F. (427 and 538 deg. C.) and a Hoskin's electric muffle furnace at 1,200 deg. F. (649 deg. C.). All temperatures up to and including 2,100 deg. F. (1,149 deg. C.) were measured by standardized 14-gage chromel-alumel couples connected to a Leeds & Northrup potentiometer. Quenching from 2,250 deg. F. (1,233 deg. C.) was controlled by a Leeds & Northrup optical pyrometer.

All tensile tests were made on a 100,000-lb. Riehle testing machine. Proportional limits were obtained from stress-strain diagrams, the deformation being taken with an extensometer reading to 0.002 in. Brinell hardness values were obtained under standard conditions (3,000 kg. load on a 10 mm. ball ±0.025 mm.) using an alpha machine, and a recording scleroscope was used for Shore hardness.

THERMAL ANALYSIS

Before carrying out the various thermal treatments heating and cooling curves were taken with the modified Rosenhain type furnace in use at the Bureau of Standards, a description of which will be found in the August, 1919, *Bulletin* of the American Institute of Mining and Metallurgical Engineers.[4] The inverse-rate curves ob-
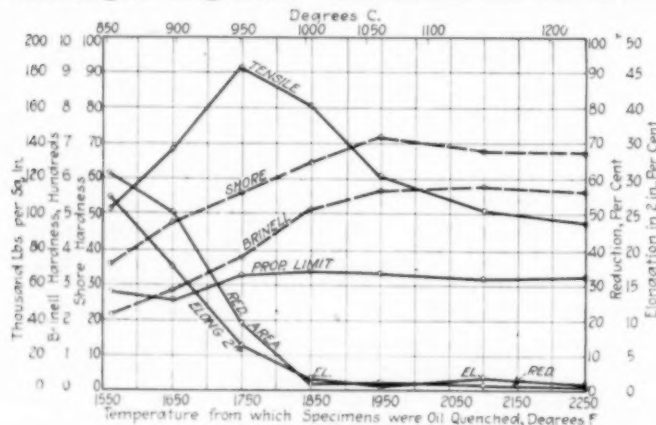

FIG. 1.   EFFECT OF VARYING QUENCHING
TEMPERATURES

tained showed discontinuities with rising temperature at 700 and 870 deg. C., and on cooling at 800 and 700 deg. C. (approximately).

VARYING QUENCHING TEMPERATURES

The effects on tensile properties and hardness of varying the oil-quenching temperature are shown in Fig. 1, based on experimental results.   For the temperatures chosen interesting features are noted:

(a) The best combination of strength and ductility is obtained in quenching from 1,750 deg. F. (953 deg. C.), which condition is coincident with maximum tensile strength.

(b) Maximum hardness and maximum strength do not coincide.

(c) Ductility, as measured by both elongation and reduction, decreases rapidly as quenching temperature is increased.   It reaches a very low value at 1,850 deg. F. (1,010 deg. C.), above which temperature it remains practically constant.   This decrease in ductility and also increase in grain size with increase in oil-quenching temperature is clearly indicated in fractures obtained in tensile tests, as shown in Fig. 2.

(d) Minimum ductility, as measured by both elongation and reduction, does not correspond to maximum tensile strength or proportional limit.

(e) Proportional limit is a difficult factor to determine in cases where ductility is low, its exact value largely depending upon the observer.   A typical stress-strain diagram shows marked resemblance to a curved line.

VARYING TEMPERING TEMPERATURE

The effect of varying tempering temperature up to about 1,200 deg. F. (649 deg. C.) on samples previously

[4]H. Scott and J. R. Freeman, Jr., "Use of a Modified Rosenhain Furnace for Thermal Analysis," *Bull.* A.I.M.E., No. 152 (1919), pp. 1429-1435.

FIG. 3.   EFFECT OF DIFFERENT ANNEALS ON STAINLESS
STEEL QUENCHED FROM 1,750 DEG. F.

quenched from 1,750 deg. F. (953 deg. C.) and 2,100 deg. F. (1,149 deg. C.) is shown in Figs. 3 and 4.   It is interesting to note that the strength of this steel is not lowered upon tempering for short periods of time until a temperature in the neighborhood of 800 deg. F. (427 deg. C.) is reached.   Between 800 deg. F. (427 deg. C.) and 1,000 deg. F. (538 deg. C.) a marked decrease in strength and increase in ductility are obtained.

The inherent brittleness of those samples quenched from the higher temperatures probably accounts for the marked increase in tensile strength with increase in tempering temperature up to 800 deg. F. (427 deg. C.) on those samples quenched from 2,100 deg. F. (1,142 deg. C.), as shown in Fig. 4.   Short time tempering gradually relieves the initial stresses set up in quenching until at about 800 deg. F. (427 deg. C.) these are

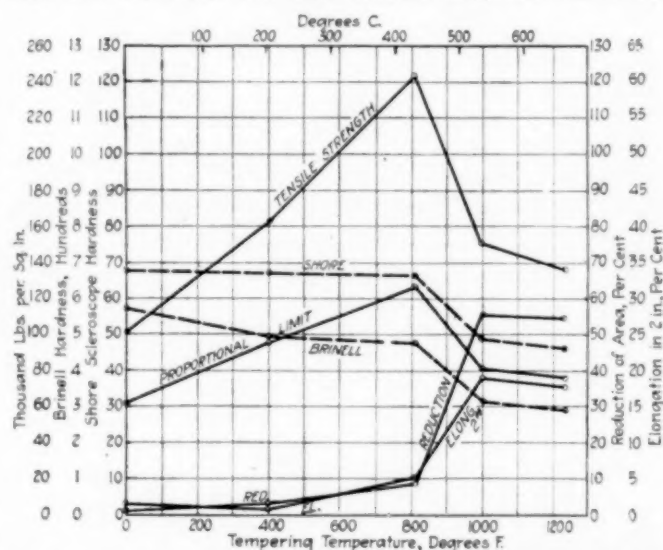FIG. 4.   EFFECT OF DIFFERENT ANNEALS ON STAINLESS
STEEL QUENCHED FROM 2,100 DEG. F.

overcome to such an extent as to allow the material to develop its maximum resistance to static tensile stress. Evidence of brittleness but to a smaller degree in those samples quenched from 1,750 deg. F (953 deg. C.) is likewise clearly shown by the shape of the tensile

FIG. 2.   FRACTURES OF QUENCHED BARS

strength curve in the range of low tempering temperatures (Fig. 3).

It is possible that the low tensile strength of these hard specimens is affected somewhat by the conditions of heating.

If the specimens are not perfectly straight, the stress applied in the testing machine is not parallel to the
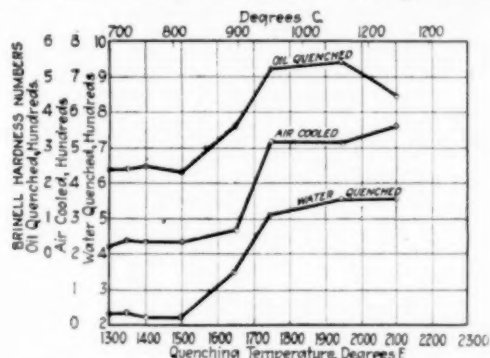
FIG. 5. HARDNESS QUENCHED DISKS, 1 IN. DIAMETER.
¼ IN. THICK

axes of the specimen and as the material has low ductility it cannot adjust itself and so breaks at a value lower than the true tensile strength. However, as all test specimens were ground after heat treatment, this effect has been kept to a minimum.

According to Guillet's constitutional diagram the steel under consideration is in the martensitic range; that is, on normal air-cooling from above the critical ranges only partial transformation of the solid solu-

tion takes place, so that on reaching room temperature martensite remains as the stable constituent. Such steel is referred to as "self-hardening steel," and it is necessary to resort to very slow cooling, as in a furnace, for annealing. Comparison of Brinell hardness values between water, oil and air cooled 6-in. thick, 1-in. disks heated to various temperatures is given in Fig. 5 and clearly indicates that the steel in small sizes will harden equally well in air as in oil or water. In practice furnace cooling from about 1,400 deg. F. (760 deg. C.) to a temperature in the neighborhood of 1,000 deg. F. (538 deg. C.) followed by air-cooling to room temperature is a satisfactory method of annealing. By heating to about 1,750 deg. F. (953 deg. C.) and cooling in a manner similar to the above, the steel is brought into an even softer condition though one not quite as satisfactory for ordinary machining.

Micro-examination of all heat-treated tensile test samples was made, and in some cases reveals interesting structures. For etching the reagent mentioned by Seidell and Horwitz[6] consisting of a mixture of 2 parts of 50 per cent solution of hydrochloric acid, 2 parts of 15 per cent solution of ammonium persulphate and 1 part of concentrated alcoholic solution of o-nitrophenol was at first used. This in general gave satisfactory results, but a mixture of 2 parts of concentrated nitric acid and 1 part of concentrated hydrochloric acid diluted with 3 parts of water was finally adopted as meeting all requirements. With this reagent satisfactory development of structure was obtained by immersion

———
[6]*Loc. cit.*
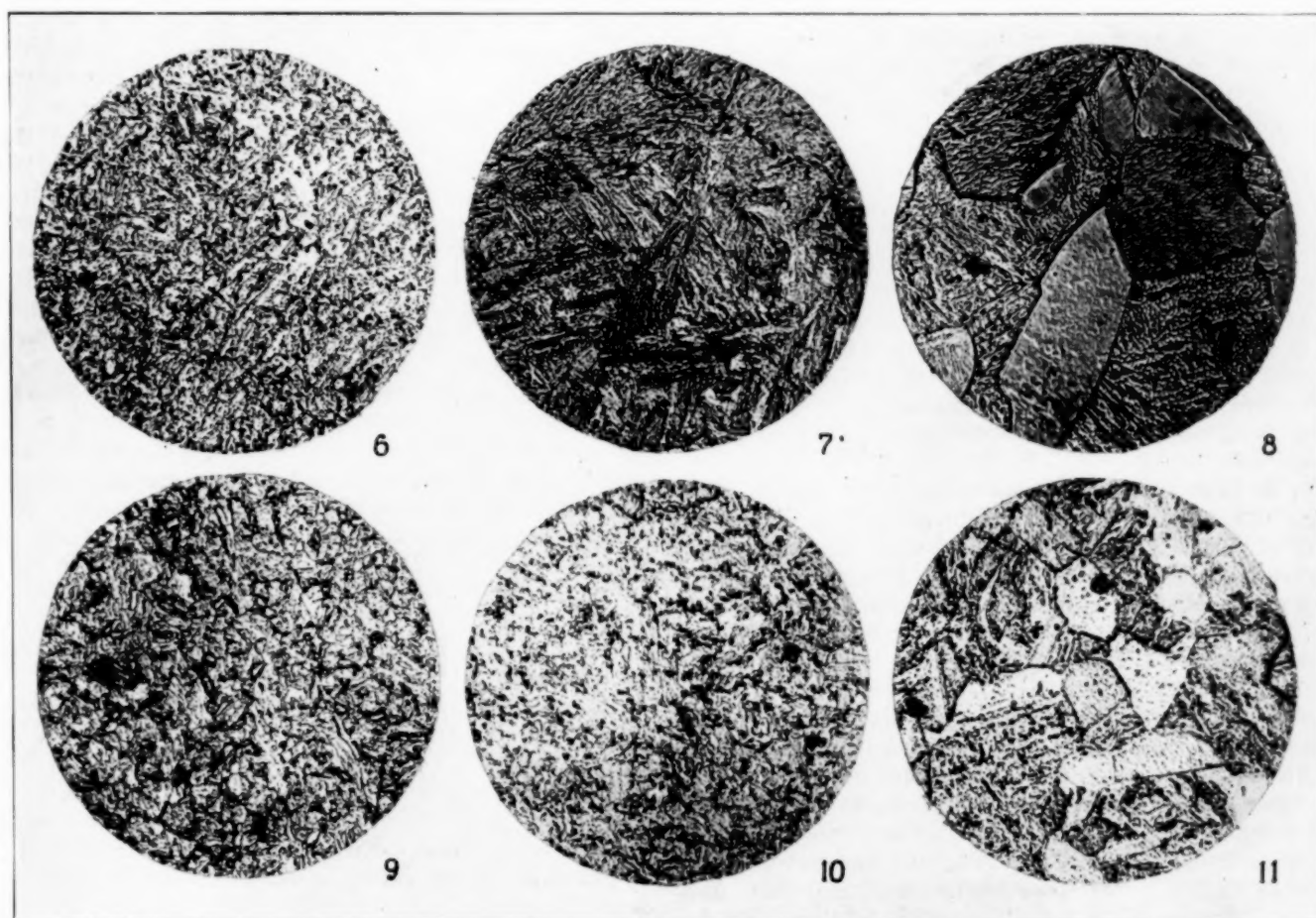
FIGS. 6 TO 11. MICROSTRUCTURE OF HEAT-TREATED SPECIMENS. × 500
Fig. 6—Oil quenched from 1,562 deg. F. Fig. 7—Oil quenched from 1,950 deg. F. Fig. 8—Oil quenched from 2,100 deg. F. Austenitic grains evident only on a portion of cross-section. Fig. 9—Oil quenched from 1,750 deg. F. Tempered 30 min. at 815 deg. F. Fig. 10—Oil quenched from 1,750 deg. F. Tempered 30 min. at 1,235 deg. F. Fig. 11—Oil quenched from 2,100 deg. F. Tempered 30 min. at 1,000 deg. F.

for from 30 to 90 seconds. Samples quenched from the highest temperatures without subsequent tempering required the longest immersion, while the remainder required only 30 to 60 seconds.

All samples oil quenched from above 1,750 deg. F. (955 deg. C.) without subsequent tempering show a martensitic structure as shown in Fig. 6. Above 1,850 deg. F. (1,010 deg. C.) the "needles" become quite large (Fig. 7) and in those samples quenched from 2,100 and 2,250 deg. F. (1,149 and 1,233 deg. C.) there is evidence of retention of the solid solution. Fig. 8 shows a portion of the cross-section of one sample, which in particular exhibits the polygonal structure characteristic of austenite. Partial preservation of these grain boundaries is also evident in a sample quenched from 3,250 deg. F.

Close examination of micrograph 6 and others not shown further reveals minute carbide globules in samples representing the steel as oil quenched from temperatures between 1,562 and 1,750 deg. F. (852 and 955 deg. C.). The steel as quenched from 1,750 deg. F. (955 deg. C.) and 2,100 deg. F. (1,149 deg. C.) and tempered at various temperatures between 400 and 1,235 deg. F. (206 and 668 deg. C.) shows similar features as illustrated in Figs. 9, 10 and 11. Samples quenched from the lower temperature show a partial precipitation of carbide (Fig. 9), while those first quenched from the higher heat are practically free from this constituent until tempered at 1,000 deg. F. (538 deg. C.) or above, but show evidence of retention of polyhedral grain boundaries even when tempered at the higher tempering temperatures used (Fig. 11).

It is interesting to note that the structures obtained in quenching generally persist even at tempering temperatures fairly close to the critical ranges, a phenomenon which is undoubtedly directly associated with the special properties of this steel.

SUMMARY

Samples of a high-chromium steel quenched in oil from various temperatures show:

(*a*) That with increasing quenching temperature hardness as measured by Brinell and Shore instruments increases until a temperature of about 1,950 deg. F. (1,066 deg. C.) is reached. Maximum range of hardness is generally obtained by quenching from this temperature up to the highest heat used, but in some cases this hardness actually decreases due to retention of the solid solution.

(*b*) That quenching from about 1,750 deg. F. (955 deg. C.) develops the best combination of strength and ductility which is not coincident with range of maximum hardness. Quenching from this or lower temperatures does not retain all the carbide in solution as is the case in samples quenched from considerably higher temperatures (notably 2,100 and 2,250 deg. F. (1,149 and 1,232 deg. C.).

(*c*) That ductility as measured by elongation and reduction is very low in those samples quenched from 1,850 deg. F. (1,010 deg. C.) or above.

Short time tempering at temperatures up to about 800 deg. F. (427 deg. C.) of samples previously quenched from both 1,750 deg. F. (955 deg. C.) and 2,100 deg. F. (1,149 deg. C.) decreases brittleness. However, ductility is increased to a greater extent in those samples quenched from 1,750 deg. F. (955 deg. C.) than in those quenched from the higher temperature.

Tempering above about 800 deg. F. (427 deg. C.)

markedly decreases strength values and hardness, which is of course accompanied by greatly increased ductility.

In general, the structure of the hardened steel tends to persist even when tempered for a short period of time at temperatures comparatively close to the lower critical range, the characteristics depending upon the quenching temperature used.

The most rapid change in tensile properties and hardness occurs in tempering between about 800 and 1,000 deg. F. (427 and 538 deg. C.).

Effects of Oils and Heat on Glues*

Plywood may be used near machinery and tanks with little likelihood of being dangerously weakened by the action of oil or gasoline on the glue joints. Plywood panels glued with animal, vegetable, blood albumin and casein glues were immersed for nearly a year in engine oil and gasoline. At regular intervals specimens were removed from the liquids and tested for joint strength. All the glues weakened somewhat during the early part of the test, the animal and vegetable glues more than the casein and blood albumin glues. The total loss of strength in any case, however, was small enough to be negligible under most conditions of service. A glue shear strength of 100 to 125 lb. per sq.in. is considered sufficient for practically any purpose for which plywood is used. Only in two or three instances did the strength of the casein and blood albumin glues fall below 150 lb. per sq.in. Engine oil, castor oil and gasoline seemed to have practically the same effect on the glue joints.

During the forty-five weeks' test, the wood absorbed 60 per cent of its original weight in engine oil and 70 per cent of its original weight in gasoline. The absorption of these oils did not cause any noticeable swelling of the wood.

Long-continued heating, however, will reduce the strength of animal glues. Solutions of a high-grade joint glue and a veneer grade glue were heated for forty-eight hours at 104, 140 and 176 deg. F., and tested every few hours during this period for strength and viscosity.

In the first seven hours of heating at 176 deg. the veneer glue lost approximately one-half its joint strength, and the high-grade glue joints weakened almost as much. The greatest loss in the strength of the glue joints occurred at this temperature. In the solutions kept at 104 deg. there was a sudden drop in the strength of the joints made with the high-grade glue after thirty-one hours of heating, due possibly to a combination of bacterial and chemical action. The veneer glue joints showed a more gradual decrease at this temperature. The most favorable of the three temperatures tried was 140 deg., but even at this temperature an appreciable weakening in both glues was noted at the end of seven hours, and longer heating caused greater loss.

The viscosity of the high-grade glues declined more rapidly than that of the veneer glue, but at the end of the heating test the viscosity of the high-grade glue still averages higher than that of the veneer glue.

Covered glue pots were used in this experiment. When open glue pots are used the loss in strength caused by the heat is less apparent, since the loss is compensated to some extent by evaporation of the water. But the concentration of the glue solution through evaporation is an expensive means of gaining strength.

Permeability of Rubber to Gases—I

Nature of Permeability and Methods and Apparatus for Its Determination Described—Effect of Factors: Characteristics of Rubbers Used, Pressure Differences, Sheet Thicknesses, Time and Temperature*

By JUNIUS D. EDWARDS† AND S. F. PICKERING‡

RUBBER has been in everyday use as a gas-retaining material for a great many years. Nevertheless, until the recent development of the modern rubberized balloon fabric, comparatively little advance was made in our knowledge of the permeability of rubber to gases. With the development of fabrics for lighter-than-air craft came the demand for accurate methods of measuring permeability, together with a demand for the most varied kinds of information regarding the permeability relations of rubber and gases. The Bureau of Standards has already, in its Technologic Paper 113[1] (hereafter referred to as T.P. 113) published the results of an investigation of methods for the determination of the permeability of rubber to hydrogen. Correlated with that work has been the present investigation of the factors involved in the passage of gas through rubber and the permeability of rubber to different gases.

NATURE OF PERMEABILITY PROCESS

Graham[2] in his classic and pioneer work on the "Dialytic Separation of Gases by Colloid Septa" was the first to point out that the characteristic passage of gas through rubber took place by solution in the rubber and
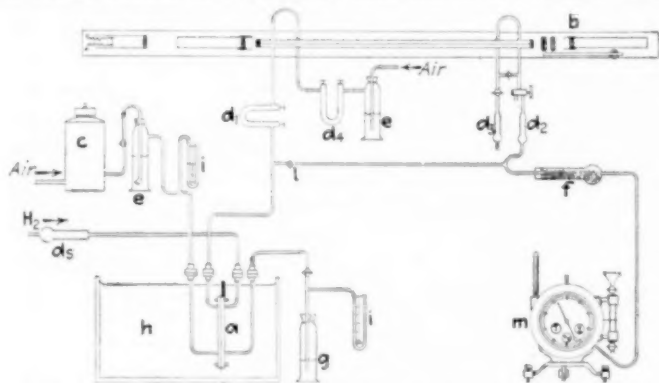

FIG. 1. DIAGRAM OF STANDARD APPARATUS FOR DETERMINING PERMEABILITY

not by diffusion through microscopic openings. If gases passed through rubber by the process of diffusion as through a porous plate, their rates of penetration should be approximately inversely proportional to their viscosities. As pointed out by Graham, the relative rates of penetration of different gases bear no relation to their densities or their viscosities. In fact, it is difficult to correlate the permeability with any of the well-known properties of the gases. It is quite obvious from a consideration of the facts that some phenomenon other than diffusion through small openings is concerned, and that the properties of both rubber and gas determine the rate of penetration.

METHODS OF DETERMINING PERMEABILITY

The permeability of a rubber film may be defined as the rate at which it is penetrated by a certain gas. Permeability will be expressed in terms of liters of gas per square meter per twenty-four hours, the volume of gas being corrected to the standard conditions of zero deg. C. and 760 mm. mercury pressure. Unless stated otherwise, all determinations are made under the following conditions, which are adopted as standard for this work: The fabric is held at a temperature of 25 deg. C. with air at atmospheric pressure (760 mm. of mercury) on one side of the fabric and the gas in question at an excess pressure of 30 mm. of water on the other side.

DESCRIPTION OF METHODS AND APPARATUS

Most of the different types of apparatus available for the determination of permeability have been described in T.P. 113, to which reference has been made. What may be called the standard apparatus of the Bureau of Standards is shown in diagram in Fig. 1. The rubber sample to be tested is held in the permeability cell *a*, which is maintained at a constant temperature in an air or water bath *h*. The cell consists of two circular plates with a shallow chamber in each. The test piece is held between the flanges of the cell and separates the two chambers; it is supported by a series of crossed wires in the form of a screen. A constant concentration of the gas whose permeability is to be measured is maintained in one chamber. The gas which penetrates the exposed area of rubber passes into the other chamber, from which it is continuously removed by a stream of air or other gas and determined quantitatively.

Because of the common use of hydrogen in balloons, the permeability to hydrogen is the property most often determined in the case of balloon fabrics. For this reason, and because of the accuracy with which the permeability to hydrogen can be determined, the permeability to any other gas will be referred to its permeability to hydrogen as the standard of comparison.

In determining the permeability to hydrogen, a current of pure dry hydrogen is passed over one side of the fabric and out through a water seal. Dry air under carefully regulated pressure is passed over the other side of the fabric, through a drying tube d_1 and into one chamber of a gas interferometer where the percentage of hydrogen in the air is determined optically. The gas then passes out through the drying tube d_2, which prevents diffusion of water vapor into the interferometer, through the saturator *f* filled with glass beads partly covered with water and then through the wet meter *m*. The saturator is employed to prevent loss of water from the meter by evaporation into the gas which

is being measured. Arrangements are made for by-passing the air stream from the interferometer to the meter when the interferometer is being read and for supplying the comparison chamber of the interferometer with pure dry air.

The gas interferometer[3] of the Rayleigh type measures the difference in refractivity of the two samples of gas contained in the gas chambers of the instrument. Several interferometers were used and their sensitivity was such that each scale division indicated from 0.007 to 0.01 per cent hydrogen in air. The average of ten settings of the instrument gave a reading which was good to somewhat better than one scale division; this gives ample precision in the determination of the hydrogen. The calibration of the interferometer, both for hydrogen and other gases, was accomplished by the method described by one of us in the *Journal* of the American Chemical Society.[4]

Characteristics of Rubber Samples Employed

The greater part of the determinations recorded were made with rubber films as they are contained in balloon fabrics. This was done not only because of the immediate application of the results in that field, but also because balloon fabrics of great variety were readily available. Rubber films of satisfactory uniformity and low permeability are also most easily secured in the form of balloon fabrics. The support given the rubber film by the cloth on which it is spread simplifies the handling and testing of the material. The question might be raised as to whether in some cases the results might not be influenced by the cloth on which the rubber is spread. To test this point, determinations were also made on thin sheet rubber in those instances. The absolute permeability of the rubber is profoundly modified by the cloth, as will be shown later; its relative permeability to different gases is apparently not affected thereby.

Relation of Permeability to Composition of Rubber

For the present purpose rubber may be considered to be a mixture of "polyprene," $(C_5H_8)_x$, in different stages of polymerization, together with resins, nitrogenous matter, water and inorganic material in varying proportions. Vulcanized rubber, which we will hereafter refer to simply as rubber, contains in addition varying proportions of sulphur, combined with or adsorbed by the polyprene together with some free sulphur. Compounding materials in great variety may also be added to the rubber to give it desirable characteristics but where imperviousness to gases is desired their use is usually restricted.

Relation Between Permeability and Composition

Without going into the detailed evidence contained in the complete report it may be desirable to summarize some of the observed facts in regard to permeability and composition:

The aging of rubber in thin films is accompanied by a characteristic decrease in permeability.

The aging of rubber is usually accompanied by a decrease in the percentage of total sulphur; the combined

sulphur increases by varying amounts and the free sulphur decreases eventually to a low value.

In one series of fabrics where the degree of cure was varied, no significant change in permeability was observed. In this case the percentage of combined sulphur varied from 0.3 to 2.5 per cent. In another series, large changes in permeability were noted with change in the degree of cure; the combined sulphur varied from 1.6 to 5.0 per cent. The original acetone extract was approximately constant in each series.

Because of the number of factors involved it would be unwise to draw any very extensive conclusions. The view is quite widely held by manufacturers and others that the permeability of a fabric can be reduced by increasing the degree of cure. Between certain limits this is true. That this reduction in permeability is caused entirely by the increase in combined sulphur is not at all certain. Opposed to this latter view is the fact that as great and greater decreases in permeability are noted on fabrics exposed to the weather where there are relatively small changes in combined sulphur. The most striking change in exposed fabrics is the increase in acetone extract, which increase is a measure of the resinification and oxidation of the rubber. It appears reasonable to believe, therefore, that an increase in combined sulphur and acetone extract each cause a decrease in permeability. This would be the natural result if hydrogen was insoluble in both the acetone-soluble material and the "polyprene sulphide."

It has been thought by some that the free sulphur plays an important part in determining the permeability. The free sulphur which is present in the colloidal condition in the rubber after vulcanization frequently crystallizes out. This is strikingly shown by the microsection of a sample of ballonet fabric illustrated in Fig. 2. The sulphur crystals are seen as dark dendritic masses in the rubber between the two plies of cloth. A certain amount of this sulphur eventually penetrates to the surface and evaporates. This process might possibly produce a certain porosity which would increase the permeability. Tests made on portions of the fabric of Fig. 2 where crystallization was extensive showed no significant difference in permeability as compared with portions where crystallization had not occurred. Certainly our tests and experimental methods have not
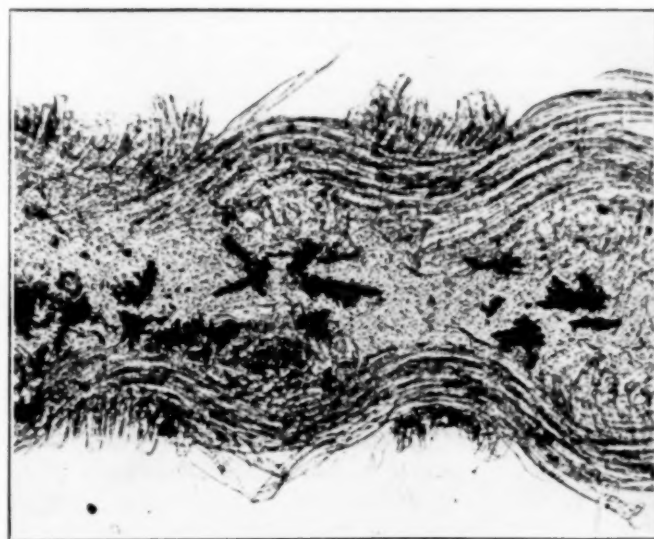

FIG. 2. MICROSECTION OF BALLONET FABRIC ($\times$ 138) SHOWING SULPHUR CRYSTALS

[3] For detailed description see L. H. Adams, *J. Am. Chem. Soc.*, vol. 37, p. 1,181; 1915.

[4] Edwards, *J. Am. Chem. Soc.*, vol. 39, p. 2,382; 1917. See also CHEM. & MET. ENG., vol. 21, p. 560; 1919.

been of sufficient delicacy to detect any effect on the permeability which can be ascribed to this blooming out of sulphur.

Compounding materials may be added to the rubber either to make it more impervious to gases or to give it greater durability. Paraffine and glue are two substances which are said to lower the permeability of rubber to hydrogen. It is known that either of them alone will give a film of very low permeability providing it is non-porous. Their use is not essential, how-
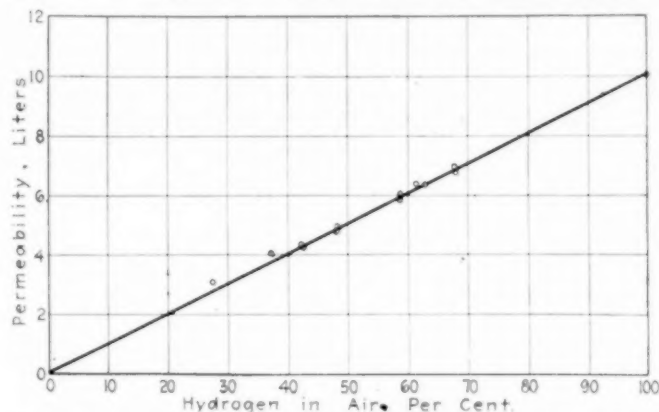

FIG. 3.   RELATION BETWEEN PERMEABILITY AND PARTIAL PRESSURE OF HYDROGEN

ever, to the production of a satisfactory coating for balloon fabrics. Lampblack, zinc oxide, litharge may be incorporated in the rubber to give it greater life by protecting the rubber from the injurious action of light.

RELATION OF PERMEABILITY TO PRESSURE

In considering the effect of pressure, a distinction should be made between the total pressure and the partial pressure of any constituent. A difference in the total pressure on the two sides will produce tension in the rubber film and a change in thickness or physical properties may result. The effect of a change in the total pressure will be influenced by the support given the rubber film such as when it is held between cloth of one or more plies, as in the case of a balloon fabric. The work of previous investigators indicates that the permeability of rubber to any gas is about proportional to the partial pressure of that gas. The agreement on this point is not unanimous, however, and the methods and data recorded are not satisfactory in all particulars.

In Fig. 3 is shown the relation between permeability and difference in partial pressure of hydrogen as shown by tests on six different test pieces of the same fabric. The percentages of hydrogen in the air were determined by means of the interferometer. The permeability of the different test pieces with 100 per cent hydrogen varied from 9.4 to 10.0 liters; each result was therefore multiplied by the ratio of 10 to the observed permeability at 100 per cent so that the 100 per cent value became 10 in each case and all the other values were directly comparable. It may be concluded from these results that the permeability is directly proportional to the partial pressure within the limits of experimental error. Similar results were obtained with carbon dioxide as shown in Fig. 4.

In accordance with the conclusion that the permeability was directly proportional to the partial pressure, the results of all permeability determinations have been corrected to the standard condition of a partial pressure

of 760 mm. in the following manner. For example: In one determination with carbon dioxide (99.9 per cent pure) there was 0.6 per cent carbon dioxide in the air on the opposite side of the fabric; the barometric pressure was 750 mm. and the observed permeability 20.0 liters. The corrected permeability is then equal to

$$20.0 \times \frac{760}{750} \times \frac{100.0}{99.9 - 0.6} = 20.4 \text{ liters.}$$

The change in permeability when the difference in the total pressure on the two sides of the sample is varied follows no simple law. In this case, not only does the permeability change with the change in partial pressure but also it may change with any variation in thickness caused by the tension on the rubber. Obviously the effect will vary with the support given the rubber. In the case of a balloon fabric the rubber film is given very intimate support by the cloth on which it is spread. The cloth may to some extent be prevented from stretching by the manner in which it is held in the cell during a test. In the case of a sheet of rubber such as dental dam, the only support the rubber receives is from the screen on which it rests in the cell and the fact that it is clamped at the edges. In Fig. 5 are shown the graphs of several experiments where the pressure of the hydrogen was varied. The two balloon fabrics (Nos. 50,313 and 47,174) show about the same small rate of increase of permeability with increase of pressure. The two samples of dental dam show a slightly higher rate. The extensibility of rub-

FIG. 4.   RELATION BETWEEN PERMEABILITY AND PARTIAL PRESSURE OF CARBON DIOXIDE
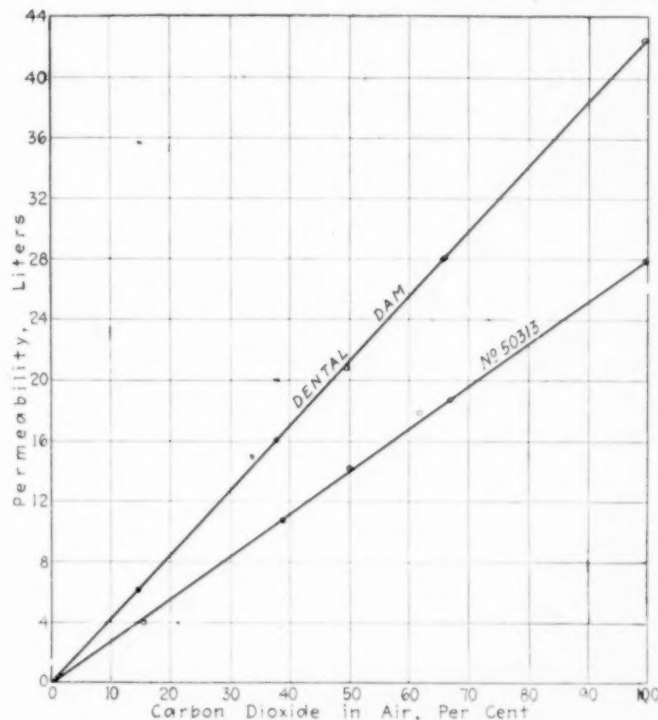
ber and cloth may vary so greatly that no great uniformity in the shape of these curves can be expected and, in general, that is our experience.

RELATION OF THICKNESS OF RUBBER TO PERMEABILITY

The permeability of a sample of rubber should obviously bear some relation to the thickness of the material. The most reasonable assumption, and the one usually

made, is that the permeability is inversely proportional to the thickness of the rubber. A series of samples of rubber, identical in chemical composition and physical properties, was not avai'able for testing this point. It was necessary, therefore, to use material from different sources and varying in composition. The samples tested varied from the thin sheet rubber known as dental dam, about 0.2 mm. in thickness, up to sheets of 2 mm. thickness. Certain of the samples were "vapor cured" with sulphur chloride and the rest steam cured in the usual manner. The permeability of these samples was determined with zero difference of pressure on the two sides of the samples in order not to introduce any variation in the tests because of stretching of the material. Their permeability was determined with a Shakespere permeameter which was furnished to us by Prof. Shakespere of Birmingham University. For descriptions of this apparatus and method the reader is referred to Reports of the British Advisory Committee for Aëronautics for the last two years, which will undoubtedly be made avai'able eventually. The instrument gives reproducible results of good precision for purposes of comparison.

The results of these tests are shown in Fig. 6, where the gas impedance, by which term the reciprocal of the permeability is designated, is plotted as a function of the thickness. There is clearly a linear relation between the two variables over a considerable range. Such uniformity as was found was hardly expected, considering the fact that the samples represented the product of a number of different makers and made no pretense of being uniform in composition. It will be noted that the very thin samples, about 0.2 to 0.3 mm. in thickness, show a lower impedance (higher permeability) than corresponds to the straight line. This

FIG. 5. RELATION BETWEEN PERMEABILITY AND TOTAL PRESSURE OF HYDROGEN

may possibly be due to the greater effect of non-uniformity in the very thin material. The sample, 0.9 mm. in thickness, which showed an impedance of over 0.6, was old and stiff and its high impedance was anticipated because of our observations on the decrease of permeability with age. This might also be inferred from its high acetone extract and combined sulphur values. The sample 1.93 mm. in thickness contains glue, which may account for its slightly greater impedance.

The results of Fig. 6 show sufficient uniformity to

warrant calculating what may be called the specific permeability of rubber. It may be defined in terms analogous to those in which such a property as thermal conductivity is defined, by stating that it is the volume of gas which passes through unit area of a sample of unit thickness in unit time with a difference in partial pressure of 760 mm. of the gas. The centimeter and minute can be conveniently used as units. The specific permeability to hydrogen at 25 deg. C. of vulcanized rubber of the character tested as calculated from the graph of Fig. 6 is 20.4×10^{-6} c.c. per minute. The

FIG. 6. RELATION BETWEEN PERMEABILITY AND THICKNESS OF RUBBER

volume of hydrogen (measured at 0 deg., 760 mm.) passing through a sample of rubber at 25 deg. C. can be approximately calculated from the following equation:

$$V = \frac{20 \times 10^{-6} \times At}{d}$$

where V is the volume in c.c., A the area in sq.cm., t the time in minutes, and d the thickness in cm.

The only other data in the literature which can be compared with the above value are those of Kayser.[a] The specific permeability to hydrogen at 25 deg. C. as calculated from Kayser's equation is 27.4×10^{-6} c.c. per minute, which value is in fair agreement with ours. Although care should be taken not to place too great reliance on any value for the specific permeability of rubber the characteristics of which are unknown, nevertheless the preceding equation will be found useful in arriving at an approximate figure in many cases. A direct permeability determination is the only sure method in any case.

The data of Fig. 6 confirm the very interesting observation of Prof. Shakespere that the gas impedance for a given weight of rubber is greatly increased by being spread on cloth. For example, a sheet of rubber (density 0.96) having a weight of 120 g. per sq.m. (about 3.5 oz. per sq.yd.) will have a thickness of 0.13 mm. and, according to Fig. 6, a permeability of $\frac{1}{0.042} =$ 23.8 liters. This weight of rubber properly spread on cloth can be made to give a fabric having a permeability of about half that value, or 10 to 12 liters. The cloth therefore performs a very important function in reducing the permeability in addition to giving the rubber support and protection. As pointed out by Prof. Shakespere, this fact is of importance in securing balloon fabrics of the lowest permeability.

TIME OF PENETRATION OF RUBBER

For some purposes, notably for use in gas masks, it is not the maximum permeability which is of most

[a]Kayser, *Wied. Ann.*, vol. 43, p. 544; 1891.

importance, but the time required for the gas to penetrate the fabric. A gas mask fabric loses its protective value about as soon as the poison gas penetrates in appreciable quantities. Permeability determinations of the kind considered in the present work are therefore of very little value in this connection.

One test made on a balloon fabric with the Shakespere permeameter indicated that hydrogen penetrated the fabric in less than 1 minute and the fabric reached its maximum permeability in from 1 to 2 minutes. These times include the lag of the instrument so that the actual time required to penetrate this fabric must be very small. The permeability of this fabric was about 8 liters per sq.m. per 24 hours. Tests made with hydrogen sulphide, in which the gas penetrating the rubber was detected with lead acetate solution, showed that rubber films of the character used in balloon fabrics were penetrated with great rapidity by hydrogen sulphide also. Any considerable time required to reach equilibrium in testing may be generally considered to be caused by instrumental lag. Sometimes, however, there are actual changes in permeability with long continued tests, which make it appear that equilibrium is being reached very slowly.

RELATION OF PERMEABILITY TO TEMPERATURE

Graham first called attention to the large temperature coefficient of permeability. The relation between temperature and permeability has been examined since then by a number of investigators, most of whom are
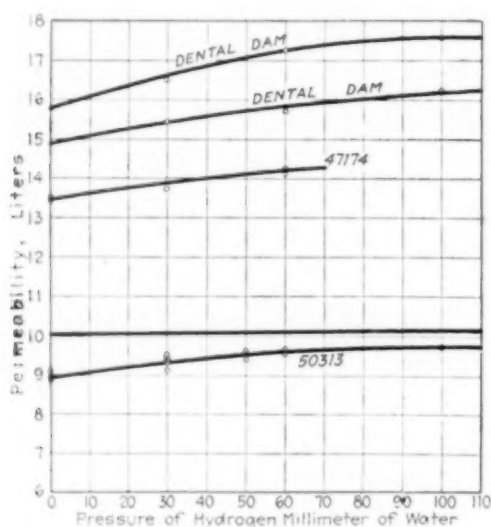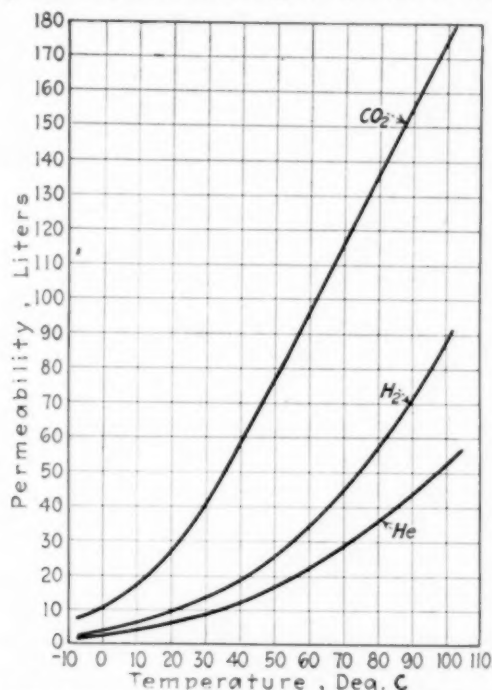

FIG. 7. RELATIVE PERMEABILITY OF RUBBER TO CARBON DIOXIDE, HYDROGEN AND HELIUM AT VARIOUS TEMPERATURES

in general agreement, although Frenzel's[6] results alone indicate that the relation is a linear one. However, there are no reliable values which cover a very large range of temperatures.

A special cell was designed for determining the permeability at different temperatures. It was similar to the regular cell, except that each half was provided with a water jacket through which water could be circulated

[6]Frenzel, Über die Gasdurchlässigkeit der Ballonstoffe." Druckerei des Elsässichen. Textilblattes im Gebweiler.

by means of a pump. By regulating the temperature of the water, the fabric could easily be kept at any desired temperature within the range covered. The temperature of the fabric itself was measured by means of a copper-constantan thermocouple of No. 36 wire whose "hot junction" was mounted on the fabric before assembling the cell.

For graphic comparison the relative permeabilities of carbon dioxide, hydrogen and helium are shown in Fig. 7. It will be noted that the curves for hydrogen and helium show about the same relative increase with temperature. The change of permeability to carbon dioxide, however, becomes practically linear after 30 deg. C. No simple relation between permeability and temperature has been discovered.

(*Part II of this paper will be published in our next issue.*)

Grave Shortage of Print Paper in United Kingdom

If the difficulties of the American newspaper publishers are considerable, they are perhaps not more embarrassing than those of their British confrères. In November last the price per ton in Scandinavia of mechanical pulp was 120 crowns, as against 330 crowns today. (The normal exchange value of the crown is $0.268.) The Scandinavian association virtually controls the market, and Lord Northcliffe's press remarks that there is nothing to prevent it from raising the price to 600 or even 900 crowns.

The *Times*, in reviewing the situation, concludes that the paper trade cannot become easier until the supply of mechanical pulp wood is enormously increased, and suggests that this be done by opening up the vast region lying between Hamilton Inlet and Lake St. John in Canada, where there is a supply of the right sort of timber sufficient to furnish the requirements of the country for years to come and where mills laid down today could be worked in eighteen months. It is explained in detail that wood can not be imported into Great Britain to be pulped on account of the expense and other insuperable difficulties.

The *Newspaper World* states that 321 newspapers have increased their price during the present year. The journal continues:

An analysis of the Board of Trade returns for the past four months shows that the average price for mechanical pulp has risen in the course of six years from about £4 10s. ($22) per ton to about £24 ($117) per ton, and for high-grade pure sulphites from £10 ($48) a ton to between £50 and £60 (between $243 and $292) per ton. Seeing that the cost of all other raw materials and chemicals is double or treble what it was, and workers' wages are, reckoned according to the time worked, more than double, it is little wonder that pure white printings at 2d. ($0.04) per pound are things of the past, and likely to be, so long as this generation lasts.

The action of the Norwegian Government with regard to paper may have an effect upon the quantity of pulp coming across to England. Some think that it will reduce the tonnage of paper being made in that country, so that the pulp mills will have more for export and will be willing to sell at a reduced price; but others consider that, as the pulp mills and paper mills so often belong to the same companies, they will want to make up on the pulp for anything they may lose on the paper from home consumption, and so will keep up the price as at present or even force it higher. If mechanical pulp advances much more, the British paper makers will be compelled to turn their attention to waste paper as a raw material to a far greater extent than they do now.

British Nitrogen Production Plans

By Frederick E. Hamer ·

THE experimental factory which the British government set about establishing during the war at Billingham-on-Tees, in the County of Durham, for the fixation of atmospheric nitrogen is at last to be turned to commercial and national account. The history of the enterprise is still somewhat obscure, and if it were fully disclosed would probably reveal the usual confusion and delays which characterize State action in such matters. It is not strictly correct to speak of a "factory." Such an establishment was contemplated and plans had been nearly completed, but with the signing of the armistice operations came to a stop. Billingham at present is understood to be little more than a site, with some partially constructed roads, a few foundations for plant, hutment accommodations for workers, etc. But as regards plant, there is practically none, and the Billingham "factory" is, like the nitrogen to be fixed, something in the air.

Of late there has been much speculation as to what was to become of the government's scheme, together with the results of the valuable research work undertaken. It is a relief to know that at last the matter has been finally settled on what is generally regarded here as a satisfactory basis. The great firm of Brunner, Mond & Co. has formed a new company, Synthetic Ammonia & Nitrates, Ltd., with a capital of £5,000,000, to take over the whole concern from the government. The company is to be British-controlled, the directors are to be British-born, and the first directors are to be approved by the government. The purchase price has not been disclosed.

Large Technical Staff Organized

In addition to acquiring the site and what stands on it at Billingham, the new company will take over the leading engineers and chemists employed by the government in research work on the subject, and with these as a nucleus has already organized a large staff of scientists and technologists. Members of this staff have already visited and inspected the German plant at Oppau, where the Haber process had been worked out. The company's experts have also visited the U. S. Government plant at Sheffield, Ala., and the General Chemical Co.'s plant at Laurel Hill, N. Y. The experimental plant of M. Georges Claude at La Grand Paroisse has likewise been inspected, and in addition the experimental plant of Dr. Maxted, one of the leading British authorities on nitrogen-fixation, has been acquired. With this very complete equipment, and with the independent research and design carried out by the company's own staff, it is claimed that the British company is now in a position to erect plant "in the full confidence that the process chosen will prove to be superior to any now in existence."

Modification of the Haber Process Chosen

The process is essentially a modification of the Haber process and was developed without any German assistance. In the matter of patents, however, the company will be fully protected by the government against German interference. It is intended to erect immediately at Billingham a plant for the manufacture of 100 tons of 100 per cent ammonia per day, equal to 150,000 (rising to 450,000) tons of sulphate per year.

It is held, however, that chloride of ammonia is equal, if not superior, to sulphate as a fertilizer, and since by converting the ammonia into this form, carbonate of soda (soda ash) can be produced (a product in which Brunner, Mond & Co. are pre-eminent), it is hoped that the agricultural community will adopt the chloride for agricultural purposes.

So far the scheme is purely commercial, but national safety in the event of another war is amply provided for—it has been, in fact, all through the primary consideration. Arrangements have been made with Explosives Trades, Ltd., to take its requirements of ammonia from the company, and to erect plant to the extent desired by the government for the oxidation of this ammonia to form nitric acid and explosives derived therefrom. The scheme generally is regarded as well planned to safeguard British interests as regards fertilizers and (in the event of war) explosives.

Another Company to Use Claude Process

Side by side with this plan may be mentioned the purchase by an English company, Cumberland Coal, Power & Chemicals, Ltd., of the rights in the Georges Claude process, which works up to pressures of 1,000 atmospheres, and which, it is claimed, is peculiarly economical on account of its simplification of plant. So far no operations have been started in England, but a director of the company informs the writer that the operation of the first commercial unit in France is most satisfactory and when the tests have been fully completed an immediate start will be made here. The first unit to be installed will correspond with a production of 50,000 tons of sulphate of ammonia a year, and in addition a small plant will be erected for the production of chloride of ammonia, this company, like the other, having a strong belief in the future of chloride as a fertilizer.

These plans contemplate an enormously increased use of ammonia in some form for agricultural purposes, and they fit in with the national demand for bringing more land into cultivation and for introducing intensive methods of cultivation to safeguard the nation against the threatened shortage of foodstuffs.

London, England.

Electrical Sterilization of Milk

The British Medical Research Committee has recently, according to *Commerce Reports*, published results of experiments in sterilization of milk by Profs. Beattie and Lewis of Liverpool University, who largely carried on the work. They enumerate the results of fifteen experiments under varying conditions, with different degrees of current and with several qualities of milk. The final conclusions arrived at by the investigators are:

Milk can be rendered free from *B. coli* and *B. tuberculosis* by the new electrical method without raising the temperature higher than 63 or 64 deg. C. This temperature effect is very short in duration and in itself is not the principal factor in the destruction of the bacteria. Though the milk is not sterilized in the strict sense of the word, the percentage reduction of the bacteria over a fortnight period is 99.93. The keeping power of the milk is considerably increased.

The taste of the milk is not altered, and so far as careful chemical examination can determine the properties of the milk are not in any way impaired. The milk may accurately be described as "raw milk" free from pathogenetic bacteria.

Oxygen the Prime Factor in Corrosion*

A Discussion of the Nature of Passivity, and the Various Characteristics of Rust and Other Oxygen-Bearing Substances in Promoting Corrosion—It Appears Impossible to Produce a Micro-Section Which Will Corrode Under Water Attack According to Crystalline Areas

By WILLIAM D. RICHARDSON

ONE who has followed the experimental work done on the corrosion of iron and steel during the past ten or fifteen years must have noticed the apparently contradictory nature of many of the experimental results and conclusions drawn from them and must have felt that the theory of corrosion lacked some essential factor or factors to make it even an approximately complete generalization. No chemist today can safely predict on the basis of theory what metal or metals will corrode most or least under a given set of conditions, even with the results of the very large number of experiments made by different investigators before him. In any given set of circumstances wherein iron and steel are exposed to the weather or to conditions which favor corrosion, there is always a doubt as to which of several metals will have the longest life and how the corrosion or pitting will proceed. The common statement of the theory of corrosion based on Nernst's theory of electromotive force,[1] while entirely convincing in the abstract, fails, when subjected to test, to explain the experimental results obtained. However, the electrolytic theory undoubtedly includes all the fundamental facts, and if it fails to explain the course of corrosion in any given instance, this is probably because some essential facts have been overlooked or have not been sufficiently emphasized and correlated.

POTENTIAL DIFFERENCE—SOLUTION PRESSURE

Corrosion depends in part on the solution pressure of iron and its place in the electrochemical series. While varying somewhat with the nature of the electrolyte used, this series as commonly given is as follows, beginning with oxygen at the negative end and ending with caesium at the positive end of the series. Hydrogen is placed differently in different tables, in some being shown as more, in others less electropositive than iron. The very lack of agreement on the exact position of a given element in the electrochemical series indicates the influence of lesser factors in locating the element in one position or another. These factors are in general

ELECTROCHEMICAL SERIES OF THE ELEMENTS

─Non-metals─	┌─────Metals─────┐		
—	Osmium	Hydrogen	Magnesium
Fluorine	Rhodium	Lead	Calcium
Oxygen	Iridium	Tin	Strontium
Chlorine	Gold	Nickel	Barium
Bromine	Platinum	Cobalt	Lithium
Iodine	Palladium	Iron	Sodium
Sulphur	Silver	Hydrogen occluded by Iron	Potassium
Phosphorus	Iron Carbide		Rubidium
Selenium	Mercury	Hydrogen	Caesium
Iron Oxides	Copper	Cadmium	+
Nitrogen	Arsenic	Zinc	
Boron	Bismuth	Manganese	
Carbon	Antimony	Chromium	
Silicon		Aluminum	

similar to those which influence and modify the course of corrosion.

In order to ascertain the place of hydrogen in relationship to iron in the electrochemical series, the following experiment was tried based on the well-known fact that a pure or nearly pure iron when soaked in dilute sulphuric acid absorbs considerable quantities of hydrogen.

Two strips of pure open-hearth iron, measuring about 1 x 3 in., were carefully cleaned by means of fine emery paper. One was allowed to soak in sulphuric acid of something less than 1 per cent strength over night. In the morning the untouched piece of metal, still bright, was once more polished with fine emery and both pieces were connected through a sensitive millivoltmeter and simultaneously plunged into neutral salt solution. The voltmeter showed the acid-soaked iron positive and the clean iron negative.

On the face of it this experiment indicates that hydrogen, or rather iron with hydrogen occluded, is electro-positive to clean iron, but it was considered that the experiment might only prove that completely reduced iron (iron with hydrogen occluded) was electro-positive to iron with oxygen condensed on its surface (clean, bright iron). However, the conditions of the experiment were similar to those which might obtain during corrosion, so that it may be accepted for practical purposes that iron with hydrogen occluded on its surface or any area of iron with hydrogen occluded is electro-positive to clean, bright iron and, of course, more so to iron with occluded oxygen or coated with oxides of iron. This holds true for water, neutral salts and generally for dilute non-oxidizing acids.

FACTORS INFLUENCING CORROSION

The main factors influencing corrosion considered in this paper are four in number:

1. Composition of the metal.
2. Physical treatment to which the metal has been subjected.
3. The influence of atmospheric oxygen (and other atmospheric constituents).
4. The influence of the products of corrosion or rust.

COMPOSITION

According to the electrolytic theory, based on the solution pressure hypothesis of Nernst, corrosion of iron has been held by many chemists to be determined by the composition of the metal, and perhaps the majority of papers written on the subject take this point of view. All of the kinds of iron and steel investigated by the writer corrode easily with the single exception of Duriron[2]. There must be some point, more or less

---

[1]Whitney, *J. Am. Chem. Soc.*, vol. 25, p. 1394.

[2]This metal is stated to contain approximately 15 per cent silicon and hence is an alloy of so different a composition from the other metals considered as to require entirely separate treatment. It is possible that there are no or few ferrite areas or surfaces exposed in this alloy and hence little opportunity for iron, owing to its solution pressure, to go into solution under any conditions even in the presence of strong and weak acids.

critical, at which corrosion or corrodibility rapidly diminishes or ceases, and the study of the composition corresponding to this point or curve region should throw much light on the general problem of corrosion. For present purposes only the ordinary types of iron and steel are under consideration and any statements made, if not otherwise qualified, refer to such varieties. Further discussion of the influence of composition on corrosion will appear later.

PHYSICAL TREATMENT

Under physical treatment are to be considered the various heat treatments, working the metal under heat, rolling and annealing, method of manufacture, etc. Some of these treatments change the composition of the metal, others only its physical structure, or, more important, its surface, and corrosion, it may not be amiss to emphasize, is distinctly a surface phenomenon. There are occasions then when physical treatment may be more important in influencing the commencement and course of corrosion than composition itself. Where deep pitting or slight but uniform general corrosion takes place its progress may be determined by so simple a factor as mill scale remaining closely adherent on certain parts of an iron surface only, and again corrosion may be prevented entirely for a long period of time by thin tightly adherent mill scale.

OXYGEN

Oxygen is considered by the writer to dominate over composition in determining the initial stages of corrosion and, acting through the medium of the products of corrosion, in determining more than any other single factor its entire course. Water is, of course, always assumed to be present either continuously or intermittently. It is possible that some corrosion results which have been reported as due to composition of the metal may have been due and perhaps determined by the physical treatment to which the metal has been subjected. On the other hand, atmospheric air or oxygen, and particularly the products of corrosion, are able to overbalance physical treatment as they are composition.

PRODUCTS OF CORROSION

The products of corrosion are themselves great accelerators of corrosion, just as mill scale is. This accelerating action is due first to the fact that the iron oxide formed during corrosion is strongly electronegative compared to iron and when concerned in corrosion is always a cathode. Ferric oxide may also act as a depolarizer in corrosion, since it is oftentimes reduced to Fe_3O_4. Its activity may be increased by condensation or adsorption of atmospheric oxygen on its surface, although Friend believes his experiments have disproved this. It also acts by absorbing and holding water.

After the commencement of corrosion, its subsequent course is determined very largely by the physical character of the rust formed, its distribution over and its adhesion to the surface of the metal. It may so act as to stimulate general corrosion. It may be responsible for deep pitting or under other circumstances may retard corrosion or prevent it altogether, for considerable periods at least, by close adhesion over considerable areas. It may cause corrosion to take different courses at different times, due to the fact that the rust formed at one time may be loose and wet, later on tightly adherent and later still dry and hard, so that by the

influence of moisture or temperature or physical strain it scales off from large surfaces, exposing the metal beneath, and the cycle is thus renewed. Altogether rust appears to be the main feature of ordinary corrosion, not only as a result, but as a causative agent.

Rust itself is dependent for its formation upon atmospheric oxygen with the slight assistance of carbon dioxide and its physical characters are developed chiefly by the conditions of corrosion. The behavior of the rust formed may also be dependent upon the physical treatment to which the metal has been subjected and to the composition of the metal, so that the conclusion appears warranted that composition of the metal, at least among the ordinary varieties of iron considered here, does not influence the progress of corrosion directly but rather indirectly through the behavior of rust and the relationship of the rust to the metal composition and surface.

Thus the products of corrosion or rust act in a dual capacity, electrochemically as accelerators of corrosion and physically as a protective against corrosion. It is needless to point out that these two ways of functioning are diametrically opposed to each other and it can easily be imagined how many types of corrosion and peculiarities and apparently unexplainable differences in corrosion might be due to this fact alone.

RELATIVE IMPORTANCE OF COMPOSITION, OXYGEN AND IRON OXIDE

The relative importance of these three factors of corrosion, and particularly the importance of composition, is of paramount interest. If oxygen determines the commencement of corrosion, and iron oxide and other products of corrosion determine its subsequent course, of what possible influence can the composition of the metal be? Composition of the metal is the one factor which can be more or less controlled for a given service. It is unthinkable that composition should not have some influence of corrosion. It is well demonstrated that irons containing much silicon, for example, do not corrode under ordinary circumstances and are very nearly insoluble in the common acids. Iron containing much nickel is also practically non-corrodible. Ordinary cast iron under many conditions corrodes less than steel or mild steel. These are well-known facts and our theories of corrosion must take them into consideration.

Apparently composition of metal does not influence corrosion directly, if we consider the ordinary varieties of iron and steel. However, the composition of the metal evidently does influence the course of corrosion profoundly in an indirect way through the influence of the products of corrosion. We have seen that the products of corrosion may behave in three different ways in influencing the course of corrosion:

1. The rust formed may fall or scale off.
2. The rust may be partially adherent and an accelerator.
3. The rust may be protectively adherent.

Naturally there may be also some intermediate stages between these three principal divisions. The physical and electrical behavior of the rust are dependent upon two factors:

1. The conditions under which the corrosion takes place.
2. The composition of the metal.

Thus, of two different metals of different compositions but subjected to the same circumstances as regards corrosion, the rust in the one case may act as an accelerator of corrosion and in the other may tend to

act rather as protective coating. In other words, the rust may tend to adhere less in one case and more in another, over smaller areas in one case and over larger areas in another, and thus, under the same conditions, one metal will corrode more and another of different composition will corrode less.

The correlation between composition and the behavior of the products of corrosion on the basis of this theory of indirect influence of composition of the metal is most important but requires a vast amount of work to bring it to a satisfactory and practical conclusion. If hydrogen is included as one of the products of corrosion, the phenomenon of polarization as a negative influence in corrosion should also be included; but in this paper by "products of corrosion" are meant the hydroxides, oxides and carbonates of iron produced during rusting in water and the salts and basic salts in salt solutions.

CORROSION OF POLISHED IRON SURFACES

A perfectly polished iron surface consists of a film of pure iron spread over the entire metal surface and covering pure iron and impurities alike. The pure iron is apparently caused to flow in such a manner as to form a mirror-like film, under the influence of the polishing powder and the friction induced by the polishing mechanism, whether hand or machine. On such a polished surface corrosion starts with some difficulty, compared with ordinary smooth, clean iron, and more particularly with rather rough but clean surfaces. It is also less easily attacked by acid. As is often found to be the case in metallographic work, when etching the polished specimens the higher the polish the more difficult it is to start the etching. Nevertheless if a drop of very pure redistilled water be placed on a highly polished iron or steel surface and allowed to dry, a spot of rust will be left. As a rule, the higher the polish the smaller will be the amount of rust remaining, and since samples of pure iron or steel take a higher polish than cast irons, the rust spot on polished cast iron is usually more prominent than on polished pure irons or steel.

If metals are polished to a high degree with perfectly dry and grease-free abrasives, a drop of water, instead of spreading over the surface, rolls up into a spheroid as though in contact with an oily surface. If the metal is capable of taking a very high polish, rust formation begins slowly at a few points only, and after the drop has dried only a small residue of rust remains, sometimes in the form of a narrow rim around the place where the drop stood. Less pure irons such as cast iron and semi-steel, which, as a rule, do not take as high a polish as pure irons and steels, also cause a drop of water to assume the spheroidal shape, but corrosion begins at numerous points and much sooner than in the other cases. In such water-drop experiments the progress of corrosion can be followed by means of a microscope or hand lens, as the greenish-white ferrous hydroxide spreads outwardly through the water from the points at which the corrosion is occuring and gradually oxidizes to red rust.

After corrosion test on polished surfaces, whether either plain water or the ferroxyl indicator in agar is used to cover an area of several inches square or more, it usually happens that there are more and larger electro-negative areas left with their original bright polish, on highly polished and comparatively pure samples than on less polished and comparatively impure samples.

The fact that the highly polished surface of iron starts to corrode more slowly than the less polished surface, such as that of cast iron or relatively less pure metal, might seem to hold out a faint hope that extreme purity of metal, if possible of attainment in a practical way, would be a means of reaching the much desired goal of corrosion-resisting iron. However, this hope does not seem warranted by the facts. Very pure open-hearth iron corrodes in the presence of oxygen more rapidly than cast iron. Electrolytic iron corrodes readily. Even highly polished surfaces corrode slightly in the beginning and at an accelerated rate after the first rust spot is formed. So long as oxygen is the dominating influence which governs the commencement of corrosion, and rust and oxygen together control the subsequent course so largely, neither pure iron nor polished surfaces appear to offer the solution of the problem.

PASSIVITY OF IRON AN OXIDATION PHENOMENON

When either commercial or electrolytic iron is immersed in strong oxidizing agents, such as chloric, chromic or fuming nitric acids, or when touched with gold or platinum while dissolving in nitric acid of sp.gr. 1.35, or when heated momentarily in air, or when it is made the positive electrode in an electrolyte containing oxygen, it becomes passive and thereafter is not attacked by ordinary acids, no longer precipitates copper, silver or lead from their salts, and in general behaves like a noble metal.

All of these processes for producing passivity in iron are oxidizing processes.

Passive iron may be reactivated by heating in a reducing atmosphere, by the action of water, salt solutions, the diluted common acids, by making it the cathode in an electrolyte, and by other means.

All of the processes for reactivating passive iron are reducing processes, since hydrogen is disengaged in all of them, including contact with water and salt solutions, as in the ordinary processes of corrosion in water.

The oxide theory[3] of passivity apparently offers the best explanation, and even though no actual oxides are formed on the surface of the iron, an equivalent gain in valence or loss of electrons can be visualized by the oxidation hypothesis and suggests an interesting parallelism between passive iron and iron covered with mill scale and adherent rust. This parallelism may be stated as follows:

If all exposed pure iron surfaces in the crystallographic sense are uniformly covered by a layer of oxide either thin or thick, and if this film be tightly adhering, no corrosion takes place. A sub-microscopic film may be assumed to be produced over an iron surface by immersion in strong oxidizing agents such as chromic and nitric acids (the passive layer), a thicker and visible layer by an oxidizing flame (mill scale) and a more irregular and thicker layer during corrosion under

[3] Dr. H. G. Byers does not accept the oxide theory of passivity, although he offers no substitute. Abstracts of his extensive investigations are found in *Chem. Abs.*, vol. 3, p. 274; vol. 4, p. 1933; vol. 6, p. 452; vol. 7, p. 318; vol. 7, p. 3268; vol. 8, p. 3738; vol. 10, p. 717. The original papers are as follows:
"The Passive State of Metals," *J. Am. Chem. Soc.*, vol. 30, pp. 1718-42.
"The Influence of the Magnetic Field on the Passive State of Iron," *J. Am. Chem. Soc.*, vol. 32, pp. 750-6.
"The Influence of the Magnetic Field on Passive Nickel and Iron," *J. Am. Chem. Soc.*, vol. 33, pp. 1757-61.
"Passivity of Iron under Boiler Conditions," *J. Am. Chem. Soc.*, vol. 34, pp. 1368-79.
"Relation Between the Magnetic Field and the Passive State of Iron," *J. Am. Chem. Soc.*, vol. 35, pp. 759-67.
"Passivity of Metals," *J. Am. Chem. Soc.*, vol. 36, pp. 2004-11.
"Anodic Relations of Passive Iron, With Notes on Polarization Potentials as Influenced by Gas Pressures," *J. Am. Chem. Soc.*, 38, pp. 362-74 (1916).

certain conditions (rust). All three types of oxide layers protect against corrosion. However, if portions of such surfaces are removed by either physical or chemical means, corrosion starts at once, the abraded or dissolved areas becoming electro-positive and the oxide areas electro-negative. In all cases corrosion is prevented or delayed until the film of oxides is lifted or removed. Iron surfaced in any of these ways may in a very large and general sense be considered passive as regards corrosion in substantially the same sense, namely, by the uniform action of oxygen on exposed ferrite areas. There may be some doubt about the exact condition of the surface in passive iron induced by treatment with oxidizing agents, one view holding that the surface is simply polarized, another that it holds condensed or occluded oxygen and another that a sub-microscopic layer of oxide has been formed, but there can be no difference of opinion about oxygen being the active agent. In the case of iron surfaces coated with magnetic oxide, the nature of the protection against corrosion is obviously both electrical and mechanical. When such a protective layer of magnetic oxide is lifted from the iron surface in places by a film of water or is removed from certain areas mechanically, the remainder acts as an accelerator of corrosion and deep pitting generally results. This is also true for adherent rust. It probably would hold for passive areas provided these could be maintained in place for considerable periods of time.

FERROXYL INDICATOR ON POLISHED AND ETCHED SURFACES

If the entire surface of a clean piece of iron be moistened and if the surface be free from oil or grease so that the water spreads over it rather uniformly, certain irregular areas will be covered with rust and other areas will not—the rusting will not be uniform, although the rust areas in some cases are large patches and in other cases very small, in the form of specks or flakes of rust. If initial rusting were guided and determined by the composition of the iron, one might naturally expect that the rusted areas would bear a definite relationship, when examined under the microscope, to the crystallographic structure of the metal and that if the corrosion took place under carefully regulated conditions the ferrite areas would become anodes and produce rust spots corresponding to them in area and that various segregated impurities in the iron would become cathodes and would remain bare of rust in the initial rusting, or until colloidal ferric hydroxide, moving with the electrolytic currents of corrosion, deposited on them. Nothing of this sort can be observed under the microscope, however carefully the rusting process is conducted.

In order to ascertain whether in fact ferrite areas are by their nature anodes and areas of impurities cathodes, in the rusting process, use was made of the very sensitive indicator developed by Messrs. Cushman and Walker and named by them ferroxyl indicator. Samples of all of the irons used were polished on the wheel in the ordinary way and slightly etched by nitric acid in alcohol. After the etching the acid was removed by immersion in successive beakers containing absolute alcohol and ether. Different procedures were followed, some of the samples being dried after alcohol treatment and some after ether treatment. Duplicates were dried in the air and in hydrogen and various modified manipulations were made use of. Standard ferroxyl indicator

in agar was dropped on the surfaces thus prepared and observations were made by means of a microscope of moderate power. The crystallographic structure of the metal could be readily seen and the development of the blue and red areas in the jelly could also be followed. If initial corrosion were determined by the composition of the metal, the red and blue areas should bear a definite relationship to the crystallographic structure of the metal and it would be natural to expect blue areas to form only over ferrite areas and red over impurities of various sorts. However, the red and blue areas in no case bore any definite relationship to the crystallographic structure. By no manipulation which was used could red and blue areas be made to coincide with crystallographic areas.

I do not wish to convey the impression that it would be impossible to refine the manipulation to such a degree that this correspondence might not be brought about, but in any of the manipulations adopted with any of the samples experimented on it did not occur. Mild alkaline solutions were tried for the neutralization of acids used in etching, the alkali afterward being removed by absolute alcohol and ether and the drying being conducted both in air and hydrogen. But in this series of experiments the results were like the previous ones in that there was no correspondence between crystallographic areas and anode and cathode areas as indicated by the ferroxyl reagent.

OXYGEN DOMINATES IN INITIAL CORROSION

All of the above experiments indicate what must have been thought by many experimenters on corrosion, that some influence dominates the composition of the metal in determining at what points or over what areas the initial corrosion may begin. This dominating influence in initial corrosion is undoubtedly oxygen. It may be oxygen which has been occluded or adsorbed by certain areas of the metal as opposed to other areas or it may be that some oxide or sub-oxide has been formed on certain areas in the form of an invisible film, but in any case the determining influence is oxygen, whether free or in combination or held to the surface by occlusion or adsorption. That it dominates over metal composition in the initial stages of corrosion can readily be demonstrated by the fact that the red areas produced by the ferroxyl indicator extend over comparatively large surfaces, considered from the standpoint of crystallography, including very many ferrite crystal surfaces in the case of a mild steel or pure open-hearth iron.

It might be argued that the preliminary treatment of the polished samples, such as the etching with an oxidizing acid, removal of the acid and the drying in air, superimpose such conditions on the iron surface that certain comparatively large areas, at any rate larger than the crystallographic units, become electro-negative under conditions favoring corrosion. It should be noted, however, that while all the samples were etched by means of nitric acid, some of them were dried in oxygen and others in hydrogen. Etching, itself, by means of acid, is a form of corrosion, and on the basis of the accepted theory presupposes polarity on the polished surface. The etched surface would not be visible under the microscope were not certain crystallographic areas attacked by the acid and certain other areas left unaffected. Etching then follows the crystallographic structure of the metal, as would be expected, and if polarity is induced by the etching process, one would naturally expect that this polarity would also be

definitely related to the crystallographic structure. We might assume that a given sample of polished iron or steel at the conclusion of the etching process would be in such condition that the subsequent corrosion under ordinary atmospheric conditions would be initiated in strict conformity with the crystallographic structure and the first corroded areas patterned after that structure. Whenever the corrosion takes place under atmospheric conditions or under water saturated with air, this is not the case. Hence again the conclusion seems warranted that some influence dominating over composition and structure of metal determines the initial course of corrosion.

Why the oxygen of the air influences considerable areas to become electro-negative is difficult to say. An ordinary iron surface is a very sensitive one as regards corrosion. The slightest film of iron oxide over pure iron makes such an area electro-negative. Areas which appear tarnished and exhibit thin-film color phenomena are electro-negative with reference to non-tarnished areas. The tarnish probably consists of an extremely thin film of iron oxide or, if the area has been in contact with acid, of an iron salt, probably a ferric salt. Everything indicates that the ordinary clean iron surface is exquisitely sensitive to numerous influences affecting corrosion, chief among which under ordinary circumstances are oxygen and the oxides of iron or rust.

THE RÔLE OF OXYGEN

The importance of oxygen in the corrosion of iron was pointed out by William H. Walker as early as 1907 and was emphasized by him and others subsequently. Walker is of the opinion that when oxygen acts in such a way as to further the process of corrosion it does so by its action on the hydrogen film which otherwise would bring the action to a close. That this action occurs and that it is catalyzed under certain conditions more than others cannot be doubted, but there is also the explanation that it may act simply and directly on the ferrous ions, changing them to ferric, and thus permitting more ferrous ions to enter the solution to restore equilibrium. At any rate, this would seem to be an explanation which accounts for the marked difference in behavior under corroding influences in the absence and presence of oxygen of such bivalent metals as aluminum and zinc as compared with iron and manganese, which are both capable of forming higher oxides and hydroxides. Air and oxygen do not accelerate the corrosion of aluminum in the presence of water to any appreciable extent. It might be argued that this is due simply to the fact that the aluminum surface does not catalyze the oxygen-hydrogen reaction as does the iron surface. Against this we have the much greater solution tension of aluminum compared with iron, one volt for aluminum as compared with 0.06 for ferrous iron. This explanation also has the advantage of agreeing with what actually and visibly occurs in corrosion experiments.

THE RÔLE OF RUST

Perhaps the most definite statements concerning rust as an accelerator of corrosion come from Friend[4]. Friend observes, "When iron has once begun to rust in air, further corrosion proceeds rapidly, until the whole surface of the metal is oxidized, even although the temperature of the air is well above dewpoint, so that a piece of bright iron exposed in a similar manner would

remain unaffected for an indefinite time." He rejects the suggestion of Kuhlmann[5] that rust acts as an oxygen carrier and thus catalytically assists further corrosion. He upholds the view held by Hutton, Grace Calvert, Wagner and Crum Brown to the effect that rust is decidedly hygroscopic and becomes charged with water in an atmosphere in which bright iron would not be affected.

Friend's experiments, however, to prove that rust does not act as an oxygen carrier may not be entirely conclusive. None of the experiments precisely corresponds to rusting in air and in water.

Friend points out that the action of rust when iron is corroding in air and submerged in water may be different. In the latter case it acts as an accelerator on account of its electro-negative character.

MILL SCALE VS. FERRIC OXIDE AS AN ACCELERATOR

Mill scale as a rule causes deeper pitting than rust, although ferric oxide, Fe_2O_3, on account of its higher degree of oxidation, should be more electro-negative than Fe_3O_4. The question naturally arises, therefore, Why does mill scale under ordinary circumstances act as a more powerful accelerator of corrosion? The answer is probably to be found in the different physical properties of the two substances as they usually occur. Ferric oxide is formed by dehydration of flocculent ferric hydroxide and is never as dense or as closely adherent as mill scale. The latter not only adheres closely but is very dense as usually formed by heat on the surface of iron and in addition is an excellent conductor. It is very difficult to obtain Fe_2O_3 of the same relative density and adhering to the surface in the same way as mill scale and it would be quite impossible to attain equal conductivity in the two substances.

DOES "BUSY IRON" CORRODE?

Engineers are unanimous in the belief that iron or steel in active service does not tend to corrode to the extent that idle iron or steel does; that the steel rail which carries many trains daily will outlast the rail carrying no trains; that the used hammer or other tool rusts less than the unused. The universal testimony of all observers indicates that their belief is well founded.

It may well be questioned whether there is anything intrinsical in use itself as affecting the metal physically, chemically or electrically, which would modify its corrodibility. The observed results are most likely due to surface changes induced by effects of service and may be explained usually by one or more of the following consequences of continued use:

1. The polishing effect of hammering or rubbing which, like all polishing actions, produces a surface which resists corrosion.

2. The shaking or rubbing off of all but tightly adherent rust which in the end forms a protective layer.

3. The accidental coating of the surface of the used iron or steel with oil or oily substances during use, which also prevents corrosion.

Cushman has suggested that continued vibration of iron or steel has the effect of equalizing potential differences, and Friend believes that in the case of "busy rails" the passage of trains keeps them above the temperature of their surroundings and tends to prevent the condensation of moisture on their surfaces. Sang has suggested that "vibration causes a shedding of the rust as soon as it is formed on the spots that are not

---

[4]Corrosion of Iron and Steel, pp. 96-98, 252-253.

[5]Dammer, Handbuch der anorganischen Chemie, 1893, III, 303.

protected by mill scale, and there is, therefore, no acceleration of the action due to the accumulation of spongy and electro-negative rust." Sang's explanation of one of the effects of vibration is undoubtedly correct as far as it goes, and Friend's idea also is undoubtedly true, but none of these explanations goes to the bottom of the matter.

The used rail or old tool generally presents two surfaces: one, a polished surface, as the head of a hammer or the top of a rail, the other a dull surface covered with brownish black closely adherent rust, as the sides of a hammer or rail. The polished surface is naturally resistant to corrosion and the tightly adherent rust protects the iron under it. That neither type of surface rusts easily is a matter of common observation. Where these two types of surface join, there is, however, the likelihood of corrosion starting whenever suitable conditions arise, as when the iron or steel becomes idle.

When a railway rail remains idle for several hours during a rain the bright upper surface invariably becomes covered with rust, but if trains are passing at frequent intervals the rust either is not formed at all or is quickly removed.

No more than a mere mention of oil on used iron is necessary. Casual reflection will indicate to anyone that the used tool or machine (or even the steel rail), when there is no intention of oiling it, is more likely to have oil dropped upon it accidentally than the unused.

Perhaps a more correct statement than the usual one of the case of "busy iron" would be to say that (in the absence of oil protection) busy iron is protected on certain surfaces by polishing action, but that on surfaces where it does corrode, it corrodes in a self-protective manner.

Analysis of High-Speed Steel

BY H. O. WARD

THE following is an analytical method that fills a long-felt want in laboratories analyzing high-speed steel in quantity. The experimental work on the method was done in the laboratory of the National Twist Drill & Tool Co., Detroit, Mich., by the author, working in collaboration with J. G. Lahr, chief research chemist of the Studebaker Corporation of America. The original feature is the method for the solution of tungsten. The method is one for the determination of manganese, chromium and vanadium in high-speed steel, using a single sample and without filtering during the operation.

A 0.5-g. sample in a 600-c.c. beaker is dissolved with 50 c.c. of sulphuric acid-silver nitrate solution[1] by the application of heat. When solution is complete 5 c.c. of nitric-phosphoric solution[2] is added. (If the tungsten does not immediately disappear, boil until the solution assumes a clear green color.) The contents of the beaker are then diluted to 200 c.c. and about 1 g. of crystals of ammonium persulphate added in small successive portions. (This will oxidize, in order, the chromium, vanadium and manganese, the last appearing as permanganic acid, giving the solution a deep pink color.) The beaker is removed from the hot plate and cooled before titrating the manganese with standard sodium arsenite solution.[3]

The contents of the beaker are now diluted to 500 c.c. and heated to boiling. A few drops of hydrochloric acid are added to destroy the permanganate coloration and precipitate the silver nitrate. Continue the boiling for at least ten minutes to expel the excess of ammonium persulphate. Cool to room temperature.

The chromium is titrated by adding an excess of standard ferrous ammonium sulphate solution[4], running in standard potassium permanganate[5] to a pink color and, after stirring for thirty seconds, destroying the excess of permanganate with standard sodium arsenite solution.

The vanadium is determined immediately after the chromium by first adding 10 c.c. of standard ferrous ammonium sulphate solution, destroying the excess by adding 10 c.c. of ammonium persulphate solution,[6] and titrating with standard potassium permanganate (for vanadium) solution.[7] Here again an excess of permanganate is added and titrated back with standard sodium arsenite solution (so using the same arsenite solution for the manganese, chromium and vanadium titrations).

CALCULATIONS

Manganese. Number c.c. of sodium arsenite solution divided by 5 multiplied by 0.1 = per cent Mn.

Chromium. Number c.c. of ferrous ammonium sulphate solution less number c.c. of potassium permanganate solution multiplied by 0.1 = per cent Cr. Ferrous ammonium sulphate must be corrected to the permanganate value before the subtraction and the permanganate corrected for the amount destroyed by the arsenite solution. The arsenite is compared to the permanganate to find out how many c.c. of arsenite 1 c.c. of permanganate is equal to. Then the number c.c. of arsenite used in the titration is divided by this value and the result subtracted from the permanganate used.

Vanadium. Number c.c. of potassium permanganate solution used less the arsenite as in the case of chromium determination multiplied by 0.2 = per cent V.

When the nitric-phosphoric solution is added it not only oxidizes the iron, carbides and tungsten present but also dissolves the tungstic acid formed, the tungsten forming a phospho-tungstate much the same as molybdenum will do under similar conditions. This saves the process of filtering. However, a little tungstic acid remaining in the solution will do no harm. If the solution is dark colored and not a clear green when diluted the first time, you may be sure it was not boiling when the nitric-phosphoric solution was added. The slight opalescence due to the presence of silver chloride in the solution will not be a detriment but rather a help, as it more distinctly shows the delicate color changes found in the chromium and vanadium titrations.

The arsenite determinations are recommended by several authorities such as Lord and Scott. The addition of the arsenite titration here adds probably 50 per cent more speed to the titration proper.

National Twist Drill & Tool Co.,
Detroit, Mich.

[1] Sulphuric acid-silver nitrate solution. 3 l. sulphuric acid (conc.). 15 l. water distilled. 27 g. silver nitrate c.p. crystals.
[2] Nitric-phosphoric solution. 50 per cent nitric acid (conc.). 50 per cent phosphoric acid. U. S. P. syrup.
[3] Sodium arsenite solution. Stock solution: 4 g. arsenious oxide per liter. 16 g. sodium carbonate per liter. Solution for use: 100 c.c. stock solution. 900 c.c. water distilled.

[4] Ferrous ammonium sulphate solution. 11.1296 g. per liter c.p. crystals. 10 c.c. sulphuric acid (conc.). Standardize against permanganate.
[5] Potassium permanganate solution. 0.9117 g. c.p. crystals per liter. 0.02885 normal. 0.0580 g. sodium oxalate = 30 c.c. of solution.
[6] Potassium permanganate solution (for vanadium). 0.6200 g. c.p. crystals per liter. 0.01961 normal. 0.0402 g. sodium oxalate = 30 c.c. of solution.
[7] Ammonium persulphate solution. 125 g. per liter c.p. crystals.

Electric Smelting of Iron Ore With Coke*

By Georg Stig, Met. E.

ALTHOUGH pig iron must be considered as a raw material, its manufacture is nevertheless one of the most important processes in the iron and steel industry. In order to satisfy the enormous and steadily increasing demand and to attain the best economical results, it has been found necessary to produce it with coke in furnaces producing quantities as large as 700 tons per day. The change from charcoal to coke as a reducing agent required more than 100 years and took place under great difficulties and with great expenditures. It was found that a charcoal furnace was not suitable for coke, and consequently the design of the blast-furnace as well as the mode of operation had to be changed considerably before a suitable coke blast furnace was obtained. What chiefly contributed to the solution of the problem, except the change of shape, size, etc., was the increase in the temperature and the pressure of the blast.

When comparing the ordinary method for producing pig iron with the electrothermic process certain analogies will naturally be found and it might be said that the temperature and pressure of the blast in the ordinary process corresponds to the current density and the load in electric furnaces. Consequently when smelting with coke, the best results, technically as well as economically, will be obtained with furnaces capable of utilizing a great amount of power.

POSSIBILITIES OF DEVELOPMENT

It may be advantageous to enumerate here the present types of furnaces, their possibilities of development and as a consequence of this, their suitability for operation with coke.[1] According to the principal characteristics of the designs they may be tabulated as follows:

1. With single shafts.
   Electrometal.
   Harmet, etc.
2. With several shafts.
   Keller.
   The California furnaces.
   Heroult-Haanel-Tinfos.
   Helfenstein-Kopparberg.

No results from operations on a large scale are obtainable from the Harmet and Keller types of furnaces, as they have been tried with loads of only 500-600 kw. The possibility of developing the Keller type is relatively limited and the same holds probably true also of the Harmet furnace, the roof of which will cause difficulties due to lack of cooling by gas circulation.

The California furnaces and the Helfenstein furnace (and its modification ·the Kopparberg furnace) are similar inasmuch as they are all polyphase furnaces with at least two shafts and have approximately the same possibilities of development. The size is limited only by the amount of energy the electrodes can carry and by the number of shafts, which, however, in very large

furnaces will be so many as to make the operation uneconomical; the upper limit of capacity is probably 5,000 to 6,000 kw.

The Heroult-Haanel-Tinfos type is somewhat similar to the Helfenstein-Kopparberg furnace. The principal difference consists in its being a single-phase furnace with a bottom electrode. However, the voltage between the transformer busbars is only half of what it is on other types. Consequently, in order to obtain a great load, very high currents must be employed. To carry a higher current than 50,000 amp., however, is probably uneconomical, so that the maximum load is not more than 3,000 kw. It must also be borne in mind that the leads on furnaces with bottom electrodes can not be arranged so satisfactorily as on furnaces without bottom electrodes, with the result that a considerable loss of energy in the leads must be counted with when running with a high load.

The Electrometal type has without doubt the greatest possibility of development. The largest furnace built up to date for electric production of pig iron is of this type, i.e., the furnace at Domnarfvet for 7,200 kw. From the designer's point of view it is, however, possible to build furnaces for 12,000 to 15,000 kw. provided electrodes of high quality are available.

FACTORS FOR SUCCESSFUL OPERATION WITH COKE

I am giving below the results I have obtained from operating the above-mentioned furnaces with coke, but will in this connection first point out that all the difficulties with coke operation which were experienced at the trial runs·with the Electrometal furnace in Trollhättan and Hardanger, viz., bridging of the charge, cold iron, burnt roofs, etc., even the abnormally high current (with its corresponding low voltage) have occurred and occur occasionally not only in coke furnaces but also in charcoal furnaces and with all other types of furnaces. I know an electric furnace built for and operated with charcoal which exhibited the same irregular and impossible runs, as for instance the Hardanger furnace before it was rebuilt. This happened as late as 1915. It is surprising that anybody can imagine that the process will be improved only by pointing out these difficulties and consider them insurmountable; the cause ought to be ascertained in the first place and then the possibility of avoiding them discussed.

It has been shown from actual operations that the following factors are of great importance in order to obtain good results and to avoid the difficulties mentioned above:

1. The rate of melting.
2. The dimensions of the furnace hearth.
3. The shape and height of the furnace.
4. Voltage, current, current density and arrangement of the leads.
5. The composition of the charge.
6. The gas circulation (at the Electrometal furnace).

INFLUENCE OF MELTING RATE

In order to obtain a quiet and even run the melting rate is without doubt the most important factor, especially as far as the lower limit is concerned. The upper limit is not of the same great importance with furnaces without gas circulation. With furnaces of the Electrometal type, however, the highest efficiency is obtained when the gases leave the furnace at somewhat over 100 deg. C., in other words when the volume of the shaft is designed so that the melting rate is not too great.

When the melting rate is too low, short circuits and bridging of the charge often occur, and in this connection cold iron occasionally. My explanation for the occurrence of these irregularities is based on observations of a run with coke in Electrometal furnace with too large a shaft. The charge consisted exclusively of specular hematite which due to the relatively low melting rate was exposed to the reducing action of the CO gases for a very long time. During this preliminary reduction the hematite was disintegrated, and the charge descended to the crucible in the form of fine ore and coarse coke. The fines descended faster with the result that the coke accumulated in a charge between the electrodes. Now, when making artificial graphite from coke, for instance in electric furnaces, a little iron oxide is often added which acts as a catalyzer, facilitating the graphite reaction. It is therefore only natural to suppose that in the above mentioned case graphite was formed and as no more oxidizing material was added to the mass of graphite, it began to form a short circuit between the electrodes. The greater part of the fine ore descended directly to the iron and slag bath and caused a boil. It is therefore evident that bridging of the charge and cold iron may be caused simultaneously by too slow melting.

COKE TENDS TO GRAPHITIZE

It has been proven by electric measurements on the Domnarfvet and Söderfors electric furnaces made by the Electric Testing Bureau in Stockholm, that the electric current passes from one electrode to the nearest one and not, as had been previously assumed, to the one connected in series in a polyphase circuit; and, furthermore, that the drop in potential takes place principally in the electric arc and not in the charge. In consequence of this, the conductivity of the charge is of minor importance, a fact which has been confirmed in practice when melting, for instance, cast-iron borings.

From what has been said above, it appears probable that the difficulties are not caused by the high conductivity of the coke, but by its tendency to be transformed to graphite. It should be possible to avoid this by designing the furnace so that the charge arrives at the electrodes correctly proportioned. The factors which determine this are the dimensions of the furnace hearth, which, again, determine the possibility of running with an even load by means of regulating voltage only, without adjusting the electrodes.

NECESSITY OF ADJUSTING ELECTRODES

This latter circumstance is of especial importance when smelting charges of low iron content in furnaces with relatively small hearths. Probably on account of this it has been found necessary at Tinfos to resort to regulation of the electrodes, because the amount of slag and iron is so large that the iron must be tapped frequently or else the electrodes raised. An even load may, however, be maintained by regulating the transformer voltage when operating this type of furnace in case the iron content of the charge is kept at about 60 per cent. Regulation of the electrodes, however, always causes a great loss of the rich gas which is one of the great assets of this furnace. It is easily possible to keep 20 to 30 tons of iron in an Electrometal furnace without experiencing any difficulty in keeping the power within normal limits by means of regulating the voltage.

The voltage, the current and the current density must be in a certain relation to one another in order to obtain a heating area of correct size around each electrode. This fact may be visualized by comparing the electric current and its power of melting with the stream of water from a hose. The pressure of the water corresponds to the voltage and the volume of water per second to the current. Coke requires a higher temperature than charcoal to become active chemically, and this is obtained preferably with a high load, i.e., high current density.

UNIFORM GAS CIRCULATION ESSENTIAL

The distinguishing characteristic of the Electrometal furnace is the gas circulation, which, apart from the fact that it increases the reduction by the gases, distributes about one-third of the energy to the shaft. A more even temperature is thereby insured in the whole furnace, contrasting it favorably with other electric furnaces where the heat is unnecessarily concentrated around the electrodes. It is of the greatest importance that the gas circulation is adequately carried out, and for this reason the largest Electrometal furnaces are now provided with positive blowers, i.e., blowers delivering a constant volume, instead of fans with a constant pressure.

DATA ON A RUN WITH COKE

The only basis for comparison of results from furnaces of different types is the efficiency in utilization of electric energy. An Electrometal furnace, for instance, showed while operating with charcoal, an efficiency of over 80 per cent, and when operating with coke for four weeks, an efficiency of about 67 per cent. It is to be noted that the furnace in question was not designed for operation with coke, but was changed in such a way as experience had proved to be desirable for running with coke. The other types—Helfenstein, its modification Kopparberg, and Heroult-Haanel-Tinfos—did not reach a higher efficiency than about 50 per cent with the identical charge. However, the first two types can not be said to have passed the experimental stage, and the last mentioned furnace was operated with a load of about 500 kw.

The principal data from the run with coke in the Electrometal furnace are:

Average load, kw	2,632
Voltage, volts	60
Current, amp.	14,000
Average production per day, metric tons	23

After smelting was well under way the run was particularly quiet and even, without bridging of the charge or difficulties with the gas circulation, which facts also become evident from the following log:

Date	No. of Charges per Day	Date	No. of Charges per Day
17	52	23	52
18	52	24	63
19	53	25	57
20	57	26	51
21	55	27	55
22	52	28	52

MIXTURE OF COKE AND CHARCOAL SATISFACTORY

In connection with the main trial run with coke alone, the furnace was successfully run previously as well as subsequently with a mixture of coke and charcoal. The experience obtained naturally resulted in ideas regarding the use of coke alone; moreover, the test was important from an economic point of view. The substitution of 50 per cent charcoal corresponds to a lowering of the cost of the reducing agent of about 25 per cent (at peace-time figures).

The above-mentioned runs have, however, demonstrated that the Electrometal furnace is suitable for operation with coke, and I am of the opinion that a correctly designed furnace of this type at present should give the best results economically.

It is also my opinion that in order to obtain good results economically with smelting with coke, only large furnaces should be employed.

CONCLUSION

I have made this contribution to the discussion about electric smelting with coke, because I think that certain considerations have been lost sight of, especially when judging the suitability of operating the Electrometal furnaces with coke. This type has been judged only from the negative results, which have been obtained in Trollhattan and Hardanger without considering the fact that the same difficulties which were experienced there also occurred when running with charcoal, and that these were overcome by suitable changes.

Swedish Wood Pulp Industry in 1919

The last two years of the war, 1917 and 1918, were very trying for the Swedish sulphite cellulose industry, as production had to be reduced considerably owing to the shortage of certain important materials and lack of customers. With the advent of peace the industry looked forward to at least a renewal of normal output if not an increase in business.

For the first half of 1919, however, this hope was not fulfilled, as tonnage was scarce and buyers were waiting for lower prices. This resulted in sulphite mills decreasing their production and running at only 64 per cent of normal capacity. By the end of the year, however, business had picked up somewhat.

	Production, Metric Tons	Normal Capacity, Approximate, Metric Tons	Per Cent
1913	699,937	700,000	100
1914	714,747	750,000	95
1915	742,000	760,000	97
1916	771,302	790,000	98
1917	554,966	825,000	67
1918	476,307	850,000	56
1919	581,167	850,000	69

The above figures show that in 1919 production was larger than in either of the two preceding years but still represented only about 69 per cent of the full capacity of the mills.

PAPER MARKET DISORGANIZED DURING THE WAR

During the last year of the war the paper market was disorganized both in Scandinavia and Canada. Paper, particularly in England and France, was offered freely in the first half of 1919 at prices so low that with the prevailing prices for cellulose the paper manufacturers in the countries named found it impossible to manufacture the corresponding sorts of paper at prices that would even approximate those at which the foreign paper was offered. Under such conditions it was not surprising that a restriction of imports was planned by the respective governments and that the impression grew abroad that Swedish quotations were unreasonably high.

SITUATION EXPLAINED TO ENGLAND AND FRANCE

Because of the conditions, the Cellulose Association sent two of its representatives to England and France to explain the situation to the authorities as well as the customers, and point out the causes of the high cost of production and the difficulties under which the

Swedish cellulose industry labored. The results of the work of this committee were apparently fruitful, as no measures were taken to regulate or ration the imports of pulp, although a proposal to such an end had already been formulated by the Allied Commission at a meeting in London. On the other hand, both England and France continued government control of the imports of paper in order to protect the domestic paper industry and enable it to resume operations on a large scale.

SUPPLY OF PAPER SHORT AND DEMAND LARGE

The summer brought a change in the paper market. The British paper manufacturers had obtained large orders under the protection of the restricted imports of paper, and had all their paper machines working again, and an increasing activity and a livelier demand were noticeable in the paper market of other countries also. By the end of the year it became evident that there was an acute shortage of paper and a veritable scramble for paper resulted.

During the latter half of 1919 the sulphite market developed along about the same lines as the paper market. In July the British paper manufacturers began to purchase paper pulp on a large scale and the sales increased until the end of the year. It was only during the end of the last month of the year that the paper manufacturers on the Continent commenced buying. They had been holding back in the hope that the promised shipments of Canadian pulp would ease the sulphite market in Europe. In the meantime it became evident that Canada could not deliver quantities of any importance, as the paper industry of the United States alone was able to absorb the entire Canadian surplus, and the Continental manufacturers then made haste to obtain supplies in Scandinavia. The rush of orders commencing in November, 1919, continued well into the first months of 1920, resulting in sharp increase in prices.

Factors Controlling Crude Oil Prices

A report on the causes of the advance in prices of gasoline, kerosene, fuel oil and other refined petroleum products, issued by the Federal Trade Commission June 1, states that the high price is due not because of a combination in restraint of trade, but to the varying conditions of supply and demand. The enormous demand for crude oil, the decline in stocks, the increased consumption of motor fuel by the ever-growing automobile industry, the increased cost of materials, labor and drilling, together with exportation to foreign countries and lack of transportation facilities in this country, have all been factors in the cost.

To conserve our supply of petroleum, which, although at present slightly on the increase, is estimated by geologists and oil experts as none too plentiful for our own growing needs, the Commission made the following recommendations to Congress:

1. Assurance of enough crude oil for home consumption in preference to exportation for foreign needs.

2. Further study in the wasteful methods of drilling and elimination by state legislation or otherwise of uneconomic methods of production.

3. A more extensive study in the possible utilization of shale oil.

4. Investigation regarding industrial and commercial conditions in the oil trade.

Legal Notes

By Wellington Gustin

Agreement With Promoters Not the Contract of the Corporation Subsequently Organized

The Circuit Court of Appeals, Fifth District, has affirmed judgment of the U. S. District Court for the Northern District of Georgia in the suit of George Beveridge against the Crawford Cotton Mills and others. This case involves the organization and promotion of the mills, and presents a lesson to organizers.

Beveridge alleged there was an agreement between himself and the co-defendants Ingle and Comer, for the formation of a corporation to take over and operate a cotton mill owned by Ingle, and likewise a mill on which Comer had an option. In pursuance of such alleged agreement the Crawford Cotton Mills was organized. Plaintiff claimed to be an expert in the handling and weaving of textile fabrics, and that, with certain other associates, he had in operation at Cedartown, Ga., a dyeing and finishing plant, and likewise a mill for the manufacture of duck; that, being desirous of forming a connection with other duck mills to supply material for his dyeing and finishing plant, he entered into an agreement with Ingle to form a corporation to take over the White City Manufacturing Co. plant, owned by the latter.

Details of the Agreement

This agreement, it is charged, was superseded by a new agreement, entered into with both Ingle and Comer, who held an option on two other mills, known as the Edwards mill and Edwards power plant. Under this agreement the Edwards properties were to be purchased for $135,000 by the proposed corporation and such properties, together with the White City Manufacturing plant, to be acquired from Ingle for $40,000, were to be bonded for $145,000, out of which the price of the Edwards properties was to be paid, less $20,000 cash to be advanced by Ingle and Comer. There was to be borrowed from a selling agent $35,000 for operation. An expert engineer was employed, and he appraised the three properties at $242,568.20.

Corporation to Be Formed

It was alleged that it was agreed to form a corporation, to be known as the Crawford Cotton Mills, with a capital stock of $250,000, $100,000 to be preferred stock and $150,000 common stock; Ingle and Comer should receive preferred stock for the $20,000 cash advanced by them, and that Ingle should receive $40,000 of preferred stock for the White City plant and machinery and all merchandise and products on hand; that the common stock should be issued one-third to each of the parties, and they in turn should then transfer back to the company, to be held as treasury stock, all but $45,000 of the common stock, each retaining $15,000 of common stock, for which each should execute his note to the corporation; that Beveridge should be president, Ingle vice president, and Comer manager, each at a salary of $10,000, out of which salaries their notes were to be paid at the rate of $5,000 a year.

The contemplated corporation was formed, it is alleged, but the stock was not issued as per agreement; on the contrary, Ingle and Comer demanded that Beveridge pay at once $15,000 in cash for his stock, which he refused to do, but for which amount he offered to execute his note as agreed previously. He further alleges that he was then presented with a subscription blank to be signed, subscribing for 150 shares of preferred stock, at $15,000, and 500 shares of common stock at $50,000, payment to be made on the call of the board of directors; that, being satisfied that this was a scheme to freeze him out, and that Ingle and Comer, constituting a majority of the board, would at once call upon him for the full amount of $65,000, he declined to sign the subscription blank, stating that he was willing to subscribe for the stock on the conditions and terms which had been previously agreed upon, whereupon the stock in full was subscribed by Ingle and Comer and another, O'Neal.

Frozen Out, Says Plaintiff

It appears that the White City Manufacturing plant and the Edwards properties were all taken over by the corporation and bonds were issued as originally contemplated. Beveridge claimed that the corporation refused to let him have anything to do with its management and refused to pay him the salary as president agreed upon between the promoters. Beveridge alleged that his damages would amount to $50,000, or other large sum, and prayed the court that Comer and Ingle be required to specifically perform the contract entered into, and that he be decreed the owner of 150 shares of the common stock upon payment of his note for the amount, and that he be declared the president of the corporation from the date of its organization at a salary of $10,000 a year; that Ingle and Comer be decreed owners of such stock only as may have been subscribed and paid for by them, and that he have judgment against them for $50,000 damages.

In an amendment to his petition for relief, Beveridge averred that he had made a trip to Philadelphia and New York, pursuant to the alleged agreement, and there secured the services of a competent selling agent, who advanced to the company $35,000.

No Relief, Declares Court

The Court of Appeals affirmed the lower court, holding that even if plaintiff had a valid contract, his remedy was not for specific performance, but was an action in damages for its breach. It said there was no ground for equitable relief in plaintiff's claims, and further that there was a misjoinder of parties and causes of action. The court had neither authority to decree Beveridge owner of 150 shares of the company's stock, nor to declare him president of the corporation. He had no contract whatever with the Crawford Cotton Mills, and the alleged agreement was between him and the promoters of the corporation prior to its organization. The only claim he could have against the corporation, which is a distinct legal entity or individual from its promoters, is one for services rendered to it in the purchase of looms and in acquiring the sales agent, said the court.

Whatever remedy plaintiff had under his alleged agreement, if any, was at law for breach of contract, and his rights at law appear too vague and indefinite to sustain a recovery.

British Chemical Industry

FROM OUR LONDON CORRESPONDENT

London, June 7, 1920.

THE advent of the holiday season is having the usual effect upon the chemical industry and the past month has been distinctly quiet, though the general position is considered to be very satisfactory. The somewhat sensational reductions in the prices of metals, cotton and wool, together with the tail end of the wave of labor unrest, have had a temporary depressing effect, but the strong latent demand for most technical chemicals had a stabilizing influence on prices, which remain practically unchanged. Quicksilver has been a notable exception, certain stocks having been thrown on the market at a considerable sacrifice.

A REPRESENTATIVE MERCHANTS' ASSOCIATION

Under the name of the British Chemical and Dyestuffs Trades Association, the new organization foreshadowed in these columns* has now been formed and has met with a somewhat mixed reception owing to the attitude of studied aloofness which it has taken toward the original and less influential British Chemical Trade Association. The latter was originally formed by a number of the smaller firms together with two of the larger East India merchants, partly for patriotic reasons and partly, it is thought, for self-protection in regard to government restrictions and a large number of pending arbitration cases. The American Chamber of Commerce gave its support at a later date and there is no question that the association carried out valuable work at a critical time. The threatened existence of two rival associations is universally deplored and it is to be hoped that fusion will ultimately take place and that steps will be taken to arrange for friendly co-operation with similar institutions in the United States and elsewhere.

CHEMISTS INAUGURATE MASONIC LODGE

The consecration of what is believed to be the first lodge composed of analytical and manufacturing chemists took place recently at the Freemasons' Hall, its title being Radium Lodge No. 4031. The leading spirits in its formation were A. Gordon Graig, N. J. Bluman and Prof. W. R. Hodgkinson, C.B.E., formerly of the Royal Academy, Woolwich. The latter was appointed secretary.

COMMERCIAL DEVELOPMENTS

Anglo Spanish Tartar Refineries, Ltd., has been formed with a capital of about $600,000 to develop the tartaric acid industry in Spain. Formed under the auspices of the Phoenix Chemical Co., which has successfully met part of the demand in this country, a new source of supply will presumably be available to meet next year's threatened shortage. In the nitrate field, the details of the Brunner Mond-Explosives Trades acquisition have now been announced. The capital of Synthetic Ammonia & Nitrates, Ltd., is about $20,000,-000, or twice that of Atmospheric Nitrogen & Ammonia Products, Ltd. (Claude process), referred to in my last article. The projected output of the Billingham factory is 100 tons of ammonia per day, capable of rapid expansion to 300 tons per day. Interesting features are the safeguards against interference by the owners of the Haber patents—by means of compulsory licenses on a royalty basis—and for the maintenance of the company

*See CHEM. & MET. ENG., May 5, 1920, p. 828.

under British control. Explosives Trades, Ltd., is to erect the necessary plant for the oxidation of part of the company's ammonia to nitric acid for explosives manufacture and to the extent desired by the British Government. In view of the present great shortage of sulphate of ammonia, particularly for export account, these new developments of the synthetic process should be of far-reaching importance in stabilizing food supplies and incidentally in absorbing the surplus sulphuric acid production rendered available by the erection of war-time plants.

A British patent of considerable interest to the American chemical industry is that of Rossi, just published, No. 130,963, covering the extraction of potash compounds from leucites or feldspars, with simultaneous production of nitrogenous fertilizers. Rossi has found that the ordinary method of manufacturing cyanamide can be adapted to the treatment of potash-bearing rocks, the mixture of the finely ground rock with calcium carbide being heated in a stream of nitrogen in exactly the same way as in the cyanamide process, the heat of reaction being sufficient to enable considerable additions of potash-bearing rock, lime and carbon to be added to the raw mix. The potassium compounds may be either volatilized or left behind with the resulting complex nitrides to give compound fertilizers, and it is stated that the nitrogenous fertilizers are readily assimilable by the crops.

THE "POPE" OF THE BRITISH CHEMICAL INDUSTRY

The appointment of Sir William Pope to the presidency of the Society of Chemical Industry has been universally approved and the delay in making an announcement is comprehensible in view of the great responsibility attaching to the post at the present time. Sir William Pope is an ardent exponent of co-operation and federation among learned and scientific societies and has done valuable work during the war in regard to mustard gas and also in connection with various commercial developments. The Society of Chemical Industry had intended to hold its annual meeting next year in Canada, thus bringing before the whole body of its members the great developments in the chemical industrial field which have taken place during the war and since the armistice both in the United States and in the British Empire. Unfortunately it seems certain that this visit will have to be postponed and the appointment as president of the society of a man like Prof. R. F. Ruttan cannot materialize as yet. The reasons for this change in program are primarily financial, the society, in common with many other institutions of this kind, being faced with enormously enhanced charges for printing, salaries, etc., which are not adequately met by increased advertising revenue. A drastic increase in the subscription rates is probable and in the meanwhile the venue of the annual meeting next year will probably be in this country with a view to consolidating "the home front." Apart from his distinguished academic career, Sir William Pope is an ardent supporter of the new Chemical Industry Club. It may be apposite to mention here that members of the New York Chemists' Club visiting this country are *ipso facto* entitled to the privileges of membership of the Chemical Industry Club by notifying the secretary at 2, Whitehall Court, London S. W. 1. The shortage of hotel accommodation threatens to be very serious in London and American visitors should not overlook the residential facilities offered by this club.

Recent Chemical & Metallurgical Patents

British Patents

Alkali Cyanides.—In a process in which an alkali cyanide is made from nitrogen, alkali-metal compound and carbon, and the cyanide is then converted into ammonia and alkali carbonate, which is used again, the alkali carbonate, before being used again, is purified from silica, alumina, etc., by treating with carbonic acid or other acid containing no element other than carbon, hydrogen, oxygen and nitrogen, or with lime. (Br. Pat. 136,772—1919. C. T. THORSELL and H. L. R. LUNDREW, Gothenburg, Sweden, Feb. 11, 1920.)

Obtaining Textile Fibers.—Woody vegetable material, such as the stalks and other parts of plants having a hard bast, such as the rind of ramie, trees, etc., is treated successively with two liquids which tend to react within the material, generating gas. A 20 to 40 per cent alkali solution, boiling or not, may be used, and subsequently a saturated solution of an ammonium salt, such as the chloride, the material being boiled therein until the ammonia gas is completely discharged. The material is finally washed with water, which may be boiling, and dried. Ammonia gas generated within the fibers tends to split away the woody material, laying bare the fibers. (Br. Pat. 136,804—1919. M. HOFSTE, Amsterdam, Holland, Feb. 11, 1920.)

Treating Slag.—Water, with or without steam or other gases, is poured or forced into or upon molten slag so as to form a foam sufficiently liquid to be poured into molds, in which it is cooled so as to form porous bricks or insulating material. The product may be crushed or used as a filling for walls and the like. In an example, slag is heated in an electric furnace to a temperature of 1,400 deg. C. and poured in a continuous stream into a container lined with refractory material through an inlet formed in the lower part of the container. Above this inlet, one or more tuyeres are provided through which water is admitted, preferably under pressure, when the slag is on a level with or above the tuyeres. The water is added in a continuous stream, and is intimately mixed by means of a rotary stirrer mounted in the container, the stirrer being so constructed as to prevent an accumulation of solid slag on the tuyeres. The supply of water is regulated so that the temperature of the foam will be about 1,000 deg. C. At this temperature it is liquid and may be led through an overflow into molds. (Br. Pat. 136,818—1919. NORSKE AKTIESELSKALE FOR ELEKTROKEMISK INDUSTRI; Cristiania, Feb. 11, 1920.)

Alkali Valerates.—In the preparation of potassium valerate by the interaction of amyl alcohol with caustic potash according to the equation

$$C_4H_9CH_2OH + KOH = C_4H_9COOK + 4H_2$$
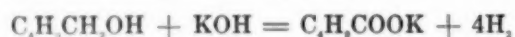
the reaction is carried out in autoclave under such a pressure as will keep the amyl alcohol, which is employed in excess, in the liquid condition at the reaction temperature, a regulating device being provided for the escape of the hydrogen. Caustic soda may replace the caustic potash. In the example, a mixture of amyl alcohol is heated to a temperature of 235 to 240 deg. C. under a pressure of 18 atmospheres. (Br. Pat. 137,064—1919. SOC. DARRASSE FRÈRES ET CIE, Vincennes, Seine, France, Feb. 25, 1920.)

Ferro-Tungsten-Chromium Alloys—Ferro-tungsten-chromium alloys for use in high-speed steels are obtained from an aluminothermic mixture containing oxides or other compounds of tungsten and chromium in chemical combination with one another, or with compounds of another metal required in the alloy. Chromic di-tungstate for use in the process is prepared from a solution of sodium tungstate with chromium sulphate in the presence of soda ash. Additional tungsten required to increase the percentage in the alloy may be precipitated from the solution as ferrous tungstate, or it may be free from combination with another metal. The carbon may be added as carbide, or steel scrap, and the balance of the iron as forge scale. The high-speed steel may be produced in one operation, or the ferro-tungsten-chromium alloy may be separately produced and afterward added to the steel. (Br. Pat. 137,080—1919. H. L. SULMAN and W. B. BALLANTINE, London, Feb. 25, 1920.)

Preserving Yeast.—In order to preserve live yeast for use in the manufacture of fertilizers or cattle foods or for other purposes, without heating, desiccating or adding inorganic chemical compounds, it is mixed with peat or powdered peat moss or tanner's bark, wood fiber or fine sawdust, and vegetable charcoal, and the whole pressed. (Br. Pat. 137,131—1919. J. R. ROBINSON, Stockton-on-Tees, Durham, Feb. 25, 1920.)

Potassium Sulphate, etc.—Finely ground potassium bisulphate and potassium chloride are mixed intimately in theoretical proportions or with a small excess of bisulphate and heated to 300 to 350 deg. C., concentrated hydrochloric acid free from sulphuric acid, and potassium sulphate almost free from chloride being obtained. When a small excess of bisulphate is used, pure sulphate may be obtained, but some sulphuric acid is expelled and is condensed. For this modification, a second heating to 700 deg. C. is employed and the two operations may be effected in a salt cake furnace. The reagents may be treated with a little water, for instance by spraying, before the reaction, but the quantity should be such that the mass remains pulverulent. (Br. Pat. 137,296—1919. FABRIQUES DE PRODUITS CHIMIQUES DE THANN ET DE MULHOUSE, Thann, France, March 3, 1920.)

Acetic Anhydride.—Acetic anhydride is prepared by heating an intimate mixture of an acetate, such as sodium acetate, with a pyrosulphate, such as sodium pyrosulphate, preferably in the presence of a diluent, such as acetic anhydride or glacial acetic acid. The acetic anhydride is distilled off as formed. The sodium pyrosulphate used may be prepared by heating sodium bisulphate. (Br. Pat. 136,574—1919. H. DREYFUS, London, Feb. 11, 1920.)

Phthalic Anhydride.—Phthalic anhydride is produced by the treatment of nitronaphthalene with sulphuric acid, not necessarily the concentrated or fuming acid, in the presence of a metal such as iron or zinc commonly used for the reduction of nitro compounds. (Br. Pat. 140,051—1919. H. SASA, Tokyo, May 5, 1920.)

Synthetic Tanning Agents.—Synthetic tanning agents are prepared by condensing aromatic sulphochlorides with the alkali-soluble fractions of anthracene oil or soft pitch, and sulphonating the condensation products so obtained. According to an example, anthracene oil or a soft pitch distillate is extracted with dilute caustic soda lye, the extract is purified and condensed with toluene sulphochloride in benzene solution, the product is sulphonated with sulphuric acid monohydrate, and the sulphonic acid converted into its sodium salt. (Br. Pat. 137,323—1919. M. MELAMID, Breslau, Germany, March 3, 1920.)

Casting Aluminum and Its Alloys.—Metal molds for using in casting aluminum and its alloys are coated with a thin layer of aluminum preferably applied by painting or spraying with aluminum bronze, the mold being afterward slowly heated to 400 deg. C. to remove all traces of the medium. Prior to pouring, the mold is heated to from 550 to 700 deg. C. Cover may be similarly coated. (Br. Pat. 137,325—1919. METAL INDUSTRIE SCHIELE & BRUCHSALER, Hornberg, Baden, Germany, March 3, 1920.)

Production of Hydrogen.—In the production of hydrogen by passing gases containing carbon monoxide with steam over a catalyst and removing the carbon dioxide with lime, a series of alternate catalytic chambers and lime chambers is employed, the pipe connections and the absorption chambers being heat insulated, so that the process is effected without loss of temperature. Pressure may be employed. The gases may be passed through a heat exchanger at the beginning and at the end of the apparatus. (Br. Pat. 137,340—1919. H. E. F. ADAMS AND H. C. GREENWOOD, London, March 3, 1920.)

Extracting and Purifying Oils.—Oils, particularly cod-liver and other fish oils, are extracted and purified by water below 100 deg. C. in presence of a current of inactive gas, such as hydrogen, carbon dioxide, nitrogen, water vapor, or a mixture of these. The oil or material is boiled at about 75 deg. C. with water in a jacketed pan connected to a vacuum pump, so that the current of water vapor is produced within the charge; low temperature steam, mixed or not with inert gas, may be injected. The water used may be fresh, salt, acid or alkaline. (Br. Pat. 137,514—1919. P. M. HAYERDAHL, Bygdo, Norway, March 10, 1920.)

Recovering Volatile Solvents.—The vapors of volatile solvents are recovered from air with which they are merged, by absorption in "active" charcoal such as that used in respirators. The charcoal is afterward heated to drive off the solvent, and the vapors are led to a condenser. Duplicate absorption chambers are used to provide for continuous operation. (Br. Pat. 137,615—1919. L. A. LEVY, London, March 3, 1920.)

Treating Ores.—Iron sand or other fine ore is briquetted to facilitate subsequent smelting, by mixing it with bituminous matter and coking the mixture in shallow open trays divided into compartments of the size and shape of the required briquets. A weight is placed on top of each compartment, or a weight may be used which affects all the compartments simultaneously; or a power press may be applied to the material before or after the distillation is completed. Lime, salt, manganese, etc., may be mixed with the material before briquetting. (Br. Pat. 137,626—1919. H. G. HILLS and E. WHEELER, Cheshire, March 10, 1920.)

Acetic Anhydride.—In the manufacture of acetic anhydride by interaction between anhydrous sodium acetate and phosgene, acetic anhydride is employed as the medium into which the reacting bodies are simultaneously introduced. The sodium acetate is kept in slight excess, and the mixture is well cooled and agitated. When the reaction is complete, a portion of the reacting mixture is withdrawn and its acetic anhydride content removed by distillation in vacuo. The remainder of the reacting mixture is used to treat further quantities of sodium acetate and phosgene. (Br. Pat. 137,701—1919. E. P. LEACH and UNITED ALKALI Co., Liverpool, March 17, 1920.)

Cellulose.—In a process for the production of hemicellulose from highly lignified plants such as wood, and of cellulose or textile fibers that can be spun from slightly lignified plants, such as jute, manila, hemp, reed grass, typha, nettles, the materials are heated under pressure in a lye containing alkaline sulphite, and sulphides with or without easily decomposable alkalis, such as sodium carbonate or soaps of alkaline metals. (Br. Pat. 137,831 —1919. C. A. BRAUN, Munich, Germany, Mar. 17, 1920.)

Purifying Sugar Juices.—In purifying thick beet and cane juices by means of sulphurous acid and lime, the thick juices are first treated to effect a separation of sugar by crystallization, and to obtain a sirup which contains more impurities and in which therefore the sulphurous acid has less tendency to produce inversion. Sulphurous acid may be passed into the sirup until it is acid. (Br. Pat. 137,849—1919. M. VON WIERNSZKOWALSKI, Leipzig, Germany, March 24, 1920.)

Phenol-Aldehyde Condensation Products. — Insoluble infusible products are obtained by the action of "pectinizing agents" upon phenol-aldehyde condensation products. According to examples, phenol is condensed with formaldehyde in the presence of slaked lime or sodium cyanide; baryta and strontia are also specified as suitable agents. The agent may be added in portions at the several stages of the condensation. The products may be used in the manufacture of varnishes, lacquers, paints, agglutinants, plastic materials, etc. (Br. Pat. 138,061—1919. L. JALOUSTRE, Z. KHEIFETZ and M. WARCHAWSKY, Paris, March 24, 1920.)

Cellulose Esters.—In the manufacture of solutions, varnishes and plastic masses from cellulose esters, for instance nitrocellulose, acetylcelluloses and nitro-acetylcellulose, the ester is dissolved or gelatinized by furfurol or a homologue or derivative thereof. The furfurol may be used alone or in conjunction with other solvents or diluents and softening or modifying agents may be added. In examples, plastic masses are obtained by kneading together acetylcellulose and alcohol; and a solution, by dissolving in furfurol, acetylcellulose soluble in tetrachlormethane, and diluting the solution, if desired, with alcohol, benzene, or even water. (Br. Pat. 138,078—1919. G. BONWITT, Berlin, March 24, 1920.

Carbazol.—In the isolation of carbazol from mixtures containing it by conversion into alkali carbazol, hydroxide of the alkali metal is added in the presence of a neutral solvent and at a temperature below the melting point of the alkali carbazol. Naphthalene is an example of a solvent which can be used at ordinary pressure; solvents of lower boiling point, such as toluene, may be employed under pressure. (Br. Pat. 139,981. BURT, BOULTON & HAYWOOD and F. D. MILES, London, May 5, 1920.)

Current Events
in the Chemical and Metallurgical Industries

Activities of the Manufacturing Chemists Association

At the recent annual meeting of the Manufacturing Chemists Association held in New York City on June 9, Henry Howard, Chairman of the Executive Committee, submitted the report of his committee for the year.

The work of this committee during the last year has largely been connected with the chemical problems arising out of the war and the termination of hostilities, particularly the work of the Chemical Foundation, and reports on various bills.

CHEMICAL FOUNDATION ADVISORY COMMITTEE

The Executive Committee feeling that the work of the Foundation would be greatly aided by the co-operation on the part of chemical and other manufacturers offered their services to help bring this condition about, and suggested that this co-operation could best be obtained by the formation of an advisory committee.

Acting upon this advice the Chemical Foundation called a meeting of its stockholders, organized them into sections according to industries, each section choosing its committee, and this committee choosing its chairman. The chairman of the various section committees formed the advisory committee and met regularly once a month in the office of the Foundation. The committee considered the most important matter accomplished so far by the Chemical Foundation was the principal adopted that there will be no limitation as to who shall be given licenses under patents provided the licensees are bona-fide American concerns, and that the patents will be worked by them in good faith and not taken out for stock jobbing purposes.

In order to secure the widest distribution possible of stock holdings in the Foundation the holdings were distributed among 160 American manufacturers, and an effort is being made to increase this number, so that each stockholder will not hold over a thousand dollars worth of stock.

Of the various bills pertaining to the chemical industry introduced into Congress since the signing of the Armistice, the Committee considered the Longworth bill (H. R. 8078) by far the most important. This bill contained provisions for licensing the importation of dyestuffs in order to protect the dye industry in America from foreign competition, and the executive committee took active part in urging its passage. Representatives of the Association appeared before the Senate Finance Committee and presented oral arguments in favor of the bill. In addition a brief was prepared by a sub-committee, under the direction of the executive committee and submitted to the State Finance Committee.

The bill is still pending and with earnest effort it should be possible to have it advanced for consideration in the Senate in the next session of Congress. It is the general belief that a majority of the Senate are not unfavorable to the bill.

The pyrites tariff bill (H. R. 5215) provided for a duty on the importation of pyrites and other crude iron sulphide minerals of 15c. per unit of sulphur content or a duty of more than 100 per cent. The committee felt that the passage of this law would be highly injurious to the chemical industry of this country and fought against it with a result that it now seems certain that the bill will not be brought up for action.

PATENT OFFICE BILL

The passage of the bill to increase the salaries of the personnel of the Patent Office was at first urged, until at the last moment a rider was tacked on incorporating the whole of another bill (S. 3223) which was opposed by the committee. At first sight, the bill had for its apparent object the rewarding of government employees who made inventions, but the proposed legislation actually provided that the Trade Commission might acquire and develop inventions, not only of Government employees, but of other individuals or agencies, which meant that the Commission could receive patents from any or all inventors throughout the United States. Having received the patents from any source, it could collect fees and royalties for licenses in such amounts and in such manner as the President should direct.

Through the National Industrial Conference Board the executive committee brought this matter before the manufacturing interests of this country with the result that the objectionable bill was amended and its enactment held up for this session.

OTHER ACTIVITIES

In addition to the above the committee has had prepared by counsel an analysis of the Peace Treaty, to bring out its effects on chemical industry. It has also prepared a statistical report on foreign trade, and kept in touch, through its membership in the National Foreign Trade Council, with trade conditions in European and other foreign countries.

The Association was represented in the International Trade Conference which was held October, 1919, at Atlantic City, by several members of the American Committee, which conferred with chemical representatives from France and Italy. The one tangible result of this conference was the decision to form an International Chamber of Commerce. The organization meeting has been called in Paris during the latter part of this month and C. Wilbur Miller of the Davison Chemical Co. will attend as a delegate.

And last but not least the committee has taken up with the Bureau of Explosives such matters as standard tests for carboys, welded drums, carboy neck protectors, new types of carboy stoppers, transportation of niter cake, hydrofluoric acid and mixed acids.

The Washington office is maintained jointly by the Manufacturing Chemists Association, the National Fertilizer Association, and the Chemical Alliance, Inc. This office has turned out to be an especially valuable adjunct to the Association.

THE CHICAGO CHEMISTS' CLUB LOUNGE

Chicago Chemists' Quarters Completed

The house warming and first "ladies night" held on the occasion of the opening of the newly-furnished lounge in the Chicago Chemists' quarters at 315 Plymouth Court on the evening of June 23 was a complete social success. Seldom are such gatherings effected and the program carried out with just the proper note of informality without loss of dignity as was manifest at this function.

Nearly one hundred members with ladies enjoyed an informal dinner and songfest in the main dining-room. After dinner the guests were introduced to the lounge, where President William Hoskins, Dr. W. Lee Lewis and Frank M. DeBeers with their ladies formed the receiving line. An excellent musical program followed by dancing completed the evening. The accompanying photograph will give some evidence of the quiet tone of refinement in this new home for Chicago Chemists.

The organization is founded for purely social purposes with a personnel composed of leaders in chemical science and industry of the Chicago district. While the success of any such body is assured through the high character of the individual members, the outward manifestation is found in the quarters they establish, just as we judge a man by the interior of his home. The atmosphere of this place cannot fail to impress the future visitor with the genial nature of the Western chemists, and leave with him a pleasurable feeling in having crossed the threshold.

Paul N. Leech, chairman, with J. A. Hynes, W. Lee Lewis and Carl S. Miner form the House Committee for the club.

Committees for Chicago Convention, A. C. S.

The following roster of committees and their respective chairmen for the fall meeting of the American Chemical Society at Chicago, Sept. 7 to 10 inclusive, was confirmed June 19 by the convention executive committee (W. Lee Lewis, chairman; R. J. Quinn, secretary):

Finance, A. M. Taylor; publicity, C. H. Jones; excursions, H. McCormack; registration and information, Glenn H. Pickard; hotels, S. L. Redman; transportation, A. E. Schaar; program, J. A. Hynes; banquet, D. K. French; men's entertainment, H. N. McCoy; ladies' entertainment, Ethel N. Terry; Relation to other scientific societies, William Hoskins.

Regulations Concerning the Chile Nitrate Industry

A cablegram received from the American Embassy at Santiago, Chile, June 10, 1920, states that at a recent session of the nitrate association it was decided to extend the date of session to June 30. The scale of prices agreed upon for delivery of nitrate were as follows: June and July, 15s. 5d. ($3.75) per Spanish quintal (101.4 lb); August, 15s. 11d. ($3.87); November, 16s. 10d. ($4.09); December to April, 17s. ($4.14). A clause protecting buyers was passed providing that in case of reduction of price the reduction rates will favor the buyer for all nitrate, not paid for, which he is under contract to receive. This agreement is valid until April 30, 1921. No sales less than fifty tons will be made for exportation, and a surcharge of 6d. will be placed upon certain amounts (not specified) up to 100 tons.

Annual Meeting of the Pacific Division, American Association for the Advancement of Science

The annual meeting of the Pacific Division, American Association for the Advancement of Science was held in Seattle, June 17, 18, 19 and brought together a large and distinguished gathering of the West's foremost scientists. The University of Washington was the scene of the many successful conferences, symposiums and sectional meetings of the affiliated societies while excursions and entertainment were provided throughout the adjoining territory.

Twenty-five societies were affiliated with the Pacific Division of the A. A. A. S., among which are included three sections of the American Chemical Society—the California, Intermountain and Puget Sound. At a very interesting joint meeting of these three sections the following program was presented:

PAPERS PRESENTED AT SECTIONAL MEETINGS

"Ammonocarbonic Acid and Its Salts," by E. C. Franklin; "The Ratio of Invert Sugar to Sucrose in Relation to the Flavor of Storage Apples," by A. W. Barton; "Destructive Distillation in the Northwest, Including Low Temperature Distillation of Lignite and of Wood," by H. K. Benson; "Improvements in the Sand Test of Detonators," by W. M. Dehn; "Sympathetic Inks in Connection with the War," by F. H. Heath; "Selenium Mustard Gas," by W. L. Semon; "The Diffusion of Sea Water in the Seattle Canal System," by T. G. Thompson; "The Magnesite Industry in the Pacific Northwest," by G. E. Whitwell.

Dr. Franklin's paper was a discussion of one phase of the important work that he has been doing for many years at Stanford University in his study of the similarity between water and ammonia as solvents and between aqua and ammono acids, bases and salts.

Of particular interest to the chemical engineer were the discussions of destructive distillation. Dr. Benson has pointed the way to the Northwest in the utilization of low grade lignites through low temperature distillation.

SYMPOSIUMS PRESENTED AT GENERAL MEETING

Of the general sessions the most important were: The symposium on the animal and plant resources of the North Pacific Ocean, in which it was pointed out that further control was necessary to insure to Alaska the continuation of its present valuable salmon and whaling industries; the research conferences in which Dr. A. O. Leuschner and Dr. F. M. Padelford, Deans of the Graduate Schools of the Universities of California and Washington, respectively, called attention to the imperative need of additional provisions necessary to keep research men in the University at this time when industry is making such successful inroads upon their number, and the symposium on the Einstein theory of relativity, in which was presented the remarkable work of the various astronomical expeditions and stations in endeavoring to experimentally determine some of the constants mathematically deduced.

EXCURSIONS

Among the excursions provided and enjoyed those of special interest were the visit to the Everett Pulp and Paper Co. where the soda process is used in the manufacture of paper from resinous mill waste; the American Nitrogen Products Co. at La Grande where 10,000 lb. of sodium nitrite is manufactured daily by arc fixa-

tion of atmospheric nitrogen and subsequent absorption of the gases by solution of soda ash; the Snoqualmie Falls, and the Snoqualmie Falls Lumber Co.

These falls, which have a depth of 268 ft., provide the hydro-electric power to operate the Snoqualmie Falls Lumber Co.'s mills. This company is unique in its application of electricity to its logging operations. It operates one mill exclusively for Douglas fir, another for hemlock and cedar, and also an electric shingle mill which has a total capacity of 500,000 ft. of lumber per day.

The 1921 meeting of the Pacific Division will be in or near San Francisco.

Accountants Association Formed

The Industrial Cost Accountants Association was organized in Chicago on the 18th of June by representatives of leading manufacturers in various lines of industry.

The object of the new association is the standardization of accounting and cost terminology and the adoption of standard governing principles; the promotion of active co-operation and interchange of average experiences between representatives of manufacturers engaged in similar activities; the education of the members and their business associates in the complex economic problems of industry; to assist standardization committees in each line of industry in establishing uniform accounting and cost practices; to act as a clearing house in distributing to all members the development in cost practices to the end that uniformity, once established, may be maintained.

MEMBERSHIP

Applicants for membership must be placed in nomination by an industrial firm or corporation, or trade organization, which must certify that the proposed member is either the owner, an officer, or a permanent employee actively engaged in the supervision of costs in such firm or corporation, or trade organization. Persons are not eligible to membership who are engaged professionally in the public practice of cost accounting on their own account, or in the employ of others so engaged. The annual dues are $25 payable in advance.

The industries represented in forming the association were the electrical, tanners (13 divisions), gear, brick, confectioners, concrete pipe, air brake, sand and gravel, farm operating equipment, cotton fabric, baking, concrete products, laundry, gas engine, and window glass manufacturers.

OFFICERS

M. F. Simmons of Schenectady, N. Y., supervisor of costs for all General Electrical Company interests, was elected president of the association. C. H. Smith of Wilmerding, Pa., director of clerical operations of the Westinghouse Air Brake Company interests, was elected first vice-president. Roland H. Zinn of New York, chief of the cost accounting bureau of the Tanners' Council, was elected second vice-president. A. A. Alles, Jr., of Pittsburgh, secretary of the Fawcus Machine Company and treasurer of the Schaffer Engineering & Equipment Company, was elected secretary-treasurer of the new organization.

Headquarters of the association will be in Pittsburgh, at the office of the Secretary-Treasurer, 1501 Peoples Bank Building.

Boston University Establishes Branch in Havana, Cuba

The subject of foreign trade has received increasing attention since the war, and its problems are being met by numerous schools and colleges in their offering of courses which are intended to train the students for effective work in the commercial world. A recent important development in this field is the establishment in Havana, Cuba, of a Spanish-American branch of the College of Business Administration incorporated in Boston University.

Dean Everett W. Lord states that the courses of the Havana branch parallel those given in Boston and lead to the same degree, bachelor of business administration. Courses are given in Spanish, with the use of textbooks prepared especially for Boston University classes. Students attending the College of Business Administration located in Boston may spend the sophomore or junior year in Havana without change of courses and without loss of time, thus having opportunity to perfect their knowledge of Spanish and to become intimately acquainted with Spanish-American life and customs. In the same way Cuban students, after a year or more at the Havana branch, may transfer to Boston to complete their course. A board of guarantors representing the leading banks and business houses of Cuba are lending their co-operation.

Endorsement of Federated American Engineering Societies by Engineering Council

At its regular meeting June 17, 1920, after hearing a report on the Organizing Conference, Engineering Council took the following actions:

Voted: that Engineering Council heartily endorse the plan of organization of the Federated American Engineering Societies and the American Engineering Council, adopted by the Organizing Conference of technical societies in Washington June 3 and 4, and authorize its Executive committee to proffer and perform on the part of Council such assistance as may be practicable in completing the work of the Organizing Conference and of the Joint Conference Committee of the Founder Societies in establishing the American Engineering Council.

Voted: that Engineering Council authorize its Executive Committee to deal with any question of co-operation with the Joint Conference Committee of the Founder Societies, relating to the permanent organization of the Federated American Engineering Societies, which may come up during the summer.

Voted: that the Secretary be instructed to invite to future meetings of Engineering Council delegates of the societies participating in the Organizing Conference in Washington, June 3 and 4, and editors of technical journals who may be interested.

Fall Meeting of the American Electrochemical Society

At the invitation of the members of the American Electrochemical Society residing at Cleveland, Ohio, supplemented by the cordial support of the local section of the American Chemical Society and the Engineers' Club, the Fall meeting of the American Electrochemical Society will be held in Cleveland, Thursday, Friday and Saturday, Sept. 30, Oct. 1 and 2. Headquarters will be at the Hotel Statler. The Engineers' Club will extend the courtesy of the use of its club rooms on the top floor of the hotel. Plans are under way which give promise of a meeting of exceptional interest. Dr. N. K. Chaney of the National Carbon Co., is in charge of local arrangements.

Personal

MARSTON T. BOGERT, professor of organic chemistry, Columbia University, New York, has declined President Wilson's appointment as a member of the U. S. Tariff Commission.

Prof. HENRY A. BUMSTEAD, director of the Sloane Physical Laboratory, Yale University, has been elected chairman of the National Research Council for the year beginning July 1.

FOSTER A. BURMINGHAM, formerly at the Pittsburgh station of the Bureau of Mines, is now a research chemist with The Brown Co., Berlin, N. H.

ARTHUR L. DAVIS, formerly of the Fixed Nitrogen Laboratory, American University, Washington, D. C., is now research chemist with the International Coal Products Corp., Newark, N. J.

E. P. DILLON, general manager of the Research Corporation, New York, has just recently returned from an extended Western trip in which he visited various Cottrell installations in the far West.

Dr. RUDOLF GAHL sailed on June 30 for Peru, where he will conduct some metallurgical investigations for the Cerro de Pasco Copper Co.

JAMES C. GRAY, senior member of the law firm of Gray, Thompson and Rose, Pittsburgh, Pa., has been elected president of the Standard Chemical Co.

J. C. INGRAM, of the American Cotton Oil Co., has been promoted to take charge of a new development department recently created by the American Cotton Oil Co. and associated corporations.

D. O. JONES, in charge of the research laboratory of the Armour Fertilizer Works, Chicago, has resigned to accept a position with the Newport Chemical Works, Carrollville, Wis.

PAUL KESTNER has been awarded the medal for the year 1920 by the Council of the Society of Chemical Industry (London) in recognition of his distinguished services to the chemical industry. He was one of the chief founders and first president of the Société de Chimie Industrielle in France, which was established in 1917. Among his notable achievements are the use of forced draughts in acid towers, automatic acid elevators, the climbing film evaporator, the scaleless water-tube boiler and other inventions in connection with beet sugar manufacture.

Dr. R. B. MOORE, chief chemist of the Bureau of Mines, and Dr. DORSEY LYON, its supervisor of station, will leave in the near future for the South to look over the possibilities of several sites which have been suggested for the new non-metallic experiment station which is to be established by the Bureau of Mines.

IRVING E. MOULTROP of Boston, at the meeting of the Trustees of the United Engineering Society, was elected as a trustee of the American Society of Mechanical Engineers and a member of the Engineering Foundation Board, to fill the vacancy caused by the death of E. Gybbon Spilsbury.

PAUL S. NICE, consulting chemist of Denver, Col., has returned after spending a few weeks in the East on a business trip. He was recently appointed engineer of tests for the Denver and Rio Grande R.R.

G. G. SWARD, duPont scholar in chemistry 1919-1920, whose graduate work was done in physical chemistry and who received the degree of Master of Science at the June commencement, has been appointed to a fellowship in the U. S. Bureau of Standards, Washington, D. C., where he began on July 1.

H. M. TRUSLER has accepted an appointment as chemist with the Proctor and Gamble Co. in their Cincinnati laboratory.

R. C. WELLS, of the chemical division of the U. S. Geological Survey, will examine some of the deposits of natural soda in the Western states during the summer.

CHARLES SPENCER WILLIAMSON, dean of the Medical School, University of Illinois, spoke before the Chicago Chemists' Club, June 22, on "Some Phases of Modern Medicine."

Current Market Reports

The Non-Ferrous Metal Market

New York, July 5, 1920.—Copper consumers are buying from spot to the end of the year, sales amounting to some 20,000,000 lb. last week in the outside market, at 18@18.50c. Tin declined slightly, but lead and zinc remained firm.

	Cents per Lb.
Copper, electrolytic	18.00@19.00
Aluminum, 98 to 99 per cent	33.00
Antimony, wholesale lots	7.50@7.75
Nickel, ordinary	43.00
Nickel, electrolytic	45.00
Tin, Straits, spot	48.00
Lead, New York, spot	8.00
Lead, E. St. Louis, spot	7.75
Zinc, spot, New York	7.75
Zinc, spot, E. St. Louis	7.50

OTHER METALS

Silver (June 24)	oz.	$0.99½
Cadmium	lb.	1.40@1.50
Bismuth (500 lb. lots)	lb.	2.70
Cobalt	lb.	2.50@3.00
Magnesium (f.o.b. Niagara Falls)	lb.	1.75
Platinum	oz.	80@90
Iridium	oz.	300
Palladium	oz.	75@85
Mercury	75 lb.	90

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	33.50
Copper bottoms	38.00
Copper rods	38.00@40.00
High brass wire and sheets	30.25
High brass rods	25.00
Low brass wire and sheets	28.50
Low brass rods	29.00
Brazed brass tubing	43.25
Brazed bronze tubing	41.75
Seamless copper tubing	34.00
Seamless high brass tubing	33.00

SCRAP METALS

	Cents per Lb. Buying Price
Aluminum, cast scrap	23.00@23.50
Aluminum, sheet scrap	23.00@23.50
Copper, heavy machinery comp.	14.50@15.00
Copper, heavy and wire	14.25@14.75
Copper, light and bottoms	12.75@13.75
Copper, heavy cut and crucible	15.00@15.50
Brass, heavy	9.00@10.00
Brass, light	7.00@7.50
No. 1 clean brass turnings	9.00@9.50
No. 1 comp. turnings	12.50@13.00
Lead, tea	4.50@5.00
Lead, heavy	6.50@7.00
Zinc, scrap	4.50@5.00

The Iron and Steel Market

Pittsburgh, July 2, 1920.

The coal car priority accorded the coal mines by the Interstate Commerce Commission order, which got into actual and general operation June 22 or 23, facilitates the production of pig iron and steel, but not its distribution. For the general good of the country the order is a good thing, but to the iron and steel producing industry it is not, directly at least, a good thing, for what the industry has needed of late is not heavier production but better facilities for shipping the product. The order increases the production and movement of coal, in which the iron and steel industry benefits, but it decreases the supplies of open top cars for shipping pig iron and steel products. As commonly applied the order includes high side gondolas in addition to drop bottom cars, which according to one definition are what are distinctly "coal cars," and as the steel industry ships fully 75 per cent of all its products in open top cars its supplies

are naturally decreased. Even cars that are received by mills with loads are sometimes taken out empty, to go to the coal mines, the mills not being permitted to load them.

COAL MINES HAVE CAR PRIORITY

A common expectation is that within a week or so from this time the coal mines will be so well supplied with cars that the railroads can relax their efforts. While the order calls for a 100 per cent car supply to coal mines, it is well recognized that the average coal mine will be unable to load cars to the extent of 100 per cent of ratings, for eventually an increase in car supplies would uncover a labor shortage, or if no labor shortage were uncovered then a lack of orders would be uncovered. The ratings are so high that shipments at rating would soon surfeit the country with coal.

Motor trucking of steel from mills in the Pittsburgh district has been increasing, and a rough estimate would be that at the present time from 2,000 to 4,000 tons of steel per working day is leaving mills in this district by truck. Most of the movement is to dealers and manufacturers in the Pittsburgh district, but there is some to railroad sidings removed from the mills, where cars may be had for loading to distant points, and there is a relatively small proportion of the steel that is being trucked long distances. The estimate just given refers only to the movement of steel to regular customers of mills having contracts and who in ordinary times get their steel by rail, and not to the trucking from warehouse that is customarily done.

DEPARTMENTS CLOSING

Not a few departments of large plants, and here and there a whole plant, either closed July 1 or will close at the end of this week, chiefly because of congestion of finished product. The disposition to close is in some instances emphasized by the moral effect the closing will have upon workmen who have been indisposed to show their normal or pre-war efficiency. In several instances departments are closed because other departments have fallen behind them, the object being to reduce the quantity of material in process. In other instances the object is to allow steel to accumulate in convenient form, as when finishing mills are closed and ingots, blooms, billets and sheet bars are accumulated, these forms admitting of convenient stocking with maximum tonnage for the space available. In some cases it is recognized that the piling of finished material at mill, against the orders of customers, has reached such a point that the customers may not want all the material at the later time at which it may become possible to ship it, there being no evidence that the consumptive requirements are increasing at this time.

There is no means of determining, or estimating with any closeness, the amount of finished steel that now lies at mill awaiting shipment. Probably 2,000,000 tons would be regarded as a low estimate, for some observers are disposed to place the total at 3,000,000 tons or more. In other terms, one might say that the accumulation is not less than one month's production at the average rate of production obtaining in 1912 and 1913, the two best tonnage years before the war, nor more than the equivalent of one month's full production at the present capacity, which is about 50 per cent greater than the capacity just before the war and about 70 per cent more than the actual production, on an average, in 1912 and 1913.

Obviously such an accumulation of steel is a serious matter. If it were shipped out suddenly, being cleared off in a period of say two months while current production were shipped at the same time, it would undoubtedly give some buyers altogether too much steel. Rail conditions are not at all likely to permit of the accumulation being moved off in any short period, but if so, then some of the steel will eventually reach customers too many months later than the time for which they specified it that it may be quite useless, the need having passed.

MARKETS QUIET

All branches of the general market are quiet, except for some insistent buying of small quantities of coke and pig iron, sending prices upwards again. Connellsville coke for spot shipment has brought as high as $18 per net ton at

ovens for both furnace and foundry grade, probably the record high in the history of the industry. Basic iron, which as noted in last report had advanced to $44, valley as minimum, has sold in a 2,000 ton lot for rather prompt shipment at $45, which possibly may now be found to be the minimum for any delivery. Bessemer remains quotable at $44 for large lots and $45 for small lots, while foundry stands at $45, valley, there being no demand except for small prompt lots.

The prices which several of the large independent steel interests have been quoting for three or four months past, including 3c. for bars, 3.10c. for shapes and 3.25c. for plates, are unchanged. There is little buying at these prices, but there is no particular pressure on the part of would-be buyers for reductions, since the common attitude of buyers is that they will buy only what they must have, paying the price asked, and will not buy any more on any terms. As long as the independents quote their higher prices the Steel Corporation experiences no difficulty in selling on contract the tonnage it is willing to allot to regular customers.

FERROALLOYS

Prompt ferromanganese continues easy at not much above the contract price of $200, delivered, still quoted for second half. Spiegeleisen is $72.50 to $75, furnace, for prompt or future. Electrolytic ferrosilicon is quite inactive, the market being nominally about $78 to $80, delivered, for 50 per cent, and about $150 for 75 per cent. Bessemer ferrosilicon remains at $62.50 for 10 per cent, $65.80 for 11 per cent and $69.10 for 12 per cent, f.o.b. furnaces at New Straitsville and Jackson, Ohio.

The Chemical and Allied Industrial Markets

New York, July 2, 1920.

The continued dullness in these markets remains unbroken. Buying interest on the whole has been indifferent except on some of the more desirable items the scarcity of which however prevents any activity worth mentioning. In investigating the *sodium salts* market it has been found that in general all grades are at least scarce and some unobtainable and that transportation difficulties are in a large part responsible for this condition. Producers are sold up on *sodium bicarbonate* and will not have any to offer for at least three months and the spot market is in the same condition with the average ranging between $2.50@$3.00 per cwt. for what little material that changed hands. The shortage of niter cake has held up the production of *sodium bisulphite* that quotations of 6c. per lb. are merely nominal as there is no material being offered.

Sodium chlorate and *cyanide* are probably in better condition than the other items in this class, *chlorate* being available on contract at 10@11c. per lb. while *cyanide* is being delivered at 25@26c. per lb. *Sodium nitrite*, which had such a sensational rise a few weeks ago, is quiet and very little demand is being exhibited; with the recent importations of this material there is now an adequate supply which is being sold around 17c. per lb. *Caustic soda, soda ash* and *sal soda* which have consistently been referred to as the "scarcer items," remain under that heading, although there have been some offerings of *caustic* made around 6c. per lb.; the present weather conditions are probr'' ʼhe reason back of this offering as this material canho be stocked in warm weather.

COAL TAR PRODUCTS

No change has been noted in the weak position of the coal tar products market as reported last week. If an accurate list of sales of the two periods could be compared the latter probably would show more declines than rises in prices, but the volume of business is so small that a comparison of this kind would not sufficiently prove the point that this market is on the downward trend. *Aniline oil* is easier and sales have come down to 32@38c. per lb. against a previous level of 35@40c., and in sympathy the *salts* are lower also, being listed at 40@45c. compared with 42@50c. per lb. of the previous week. *Beta-naphthol* is the possible exception in this market and it is now hard to obtain the sublimed grade under 90c., while the average price is nearer $1 per lb. The technical grade is also scarcer with prevailing prices ranging from 70@90c. per lb.

NAVAL STORES

This branch is marking time with the buyer waiting for still lower prices, which will probably come as the past week has shown a still further decline. Supplies are in a much better condition and arrivals from the Southern market are ample to take care of the local trade which at present is light. *Turpentine* is receding to its former level, reaching as low as $1.75 per gal., which was about the average price of six months ago. However, business has not resumed its former stride and exporting, which comprises a large part of this trade, is dull.

Baltimore, Md., June 30, 1920.

Fertilizer manufacturers in this section have been handicapped during the last week on account of an "outlaw" railroad strike resulting in an embargo not only on incoming but on outgoing shipments as well, and practically no complete fertilizer has been shipped out during the last week, although the season for wheat fertilizers is now on. It is with difficulty that the railroads are handling perishable food stuffs, but it is hoped this condition will be remedied in another week at the most.

Acid Phosphate.—The market continues firmer with practically no resale lots offering and producers well sold up for the summer months, and unable to take on but a very limited tonnage for movement by cars. The nominal quotation for 16 per cent grade, in bulk, is now $20 per ton f.o.b. cars, although some sales have been made during the past week as high as $22 per ton, in buyer's bags, f.o.b. cars Baltimore. Run of pile testing 17 to 18 per cent is quoted from $19 to $19.50, basis 16 per cent A.P.A., quantity and shipments subject to seller's approval and car supply permitting. Phosphate rock remains scarce, and there does not seem to be any relief in sight for some time to come, and even though shipments should come out from the mines in better volume during the next month or two, it is not anticipated that this will have any material bearing on the market, as an enormous tonnage will be required for next spring, and stocks of both acid phosphate and rock are running so low that the manufacturers will have to bend every effort to secure supplies of phosphate rock in order to enable them to take care of their trade next spring.

Blood and Tankage.—There has not been any change in conditions recently surrounding this material, but is is significant that producers are not pressing their packing house byproducts on the market, and are holding firm at their views ranging from $7.75 and 10c. to $8 and 10c. f.o.b. Eastern shipping points, according to test and condition of the material.

Nitrate of Soda.—The market continues firm and August to October arrivals are quoted at $3.90@$3.95, November to December, $4@$4.05, and January to April, $4.10@$4.15 ex vessels Baltimore, and sellers claim that based on the present sterling exchange rate these prices figure lower than cost of importation based on the market in Chile.

Potash.—There have been no recent arrivals, and on account of the sold-up condition of the domestic producers, spot stocks are held firmly at $2.65@$2.75 basis 80 per cent for muriate, $2.25@$2.30 per unit for manure salt, and $2.35@$2.50 for kainit. Even at these prices there is only a limited tonnage available, and with the prospect of no heavy arrivals during the summer months when the demand is comparatively light, it looks as though present quotations on spot stocks will be maintained. As yet no schedule of import prices on Alsatian potash has been announced, but these are expected momentarily. In the meantime, but few of the manufacturers have covered for their next season's requirements.

Fish Scrap.—Weather conditions during the past week have been unfavorable for the catch of menhaden fish in the Chesapeake Bay, and while quotations remain unchanged at $7.50 and 10c. for the machine dried unground scrap and $6.25 and 50c. for the acid scrap f.o.b. fish factories, some of the producers are not inclined to take on further business at these levels, anticipating a higher market will rule later on more in line with animal ammoniates.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.	—	$0.65 – $0.75
Acetone	lb.	$0.15 – $0.20	.21 – .22
Acid, acetic, 28 per cent	cwt.	3.50 – 3.75	4.00 – 4.50
Acetic, 56 per cent	cwt.	6.00 – 7.50	8.00 – 9.00
Acetic, glacial, 99½ per cent. arbov	cwt.	15.50 – 16.00	16.50 – 17.50
Boric, crystals	lb.	.15 – .15½	.15½ – .16½
Boric, powder	lb.	.15 – .15½	.15 – .16
Citric	lb.	1.05 – 1.12	1.17 – 1.18
Hydrochloric (nominal)	cwt.	2.00 – 3.00	3.10 – 3.25
Hydrofluoric, 52 per cent	lb.	.13½ – .14	.14½ – .15½
Lactic, 44 per cent tech	lb.	.11 – .11½	.12 – .16
Lactic, 22 per cent tech	lb.	.04½ – .05½	.06 – .07
Molybdic, C. P.	lb.	4.00 – 4.50	4.50 – 5.00
Muriatic, 20 deg. (see hydrochloric)			
Nitric, 40 deg	lb.	.06 – .07	.07½ – .08½
Nitric, 42 deg	lb.	.07½ – .08	.08½ – .09½
Oxalic, crystals	lb.	.55 – .57	.60 – .65
Phosphoric, Ortho, 50 per cent solution	lb.	.14 – .23	.24 – .25
Picric	lb.	.28 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.25 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	14.00 – 19.00	
Sulphuric, 60 deg., drums	ton	—	
Sulphuric, 66 deg. tank cars	ton	23.00 – 24.00	25.00 – 26.00
Sulphuric, 66 deg., drums	ton	35.00 – 40.00	45.00 – 50.00
Sulphuric, 66 deg., carboys	ton	36.00 – 40.00	50.00 – 55.00
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	37.00 – 42.00
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 – 30.00	38.00 – 42.00
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 – 35.00	40.00 –
Tannic, U. S. P.	lb.	1.45 – 1.50	1.55 – 1.60
Tannic (tech.)	lb.	—	.60 – .90
Tartaric, crystals	lb.	—	.80 – .85
Tungstic, per lb. of WO	lb.	—	1.20 – 1.40
Alcohol, Ethyl (nominal)	gal.	5.10 – 5.50	6.00 – 7.00
Alcohol, Methyl, 95%	gal.	—	2.50 – 2.70
Alcohol, Methyl, pure	gal.	—	3.50 – 3.55
Alcohol, denatured, 188 proof (nominal)	gal.	—	1.10 – 1.15
Alcohol, denatured, 190 proof (nominal)	gal.	—	1.05 – 1.10
Alum, ammonia lump	lb.	.04½ – .05	.05½ – .06
Alum, potash lump	lb.	.07½ – .08½	.09 – .09½
Alum, chrome lump	lb.	.15½ – .18	.19 – .20
Aluminum sulphate, commercial (nominal)	lb.	.02 – .03	.03½ – .04½
Aluminum sulphate, iron free	lb.	.03½ – .04	.04½ – .04½
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.07½ – .10½	.11 – .12
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.32 – .35	.35 – .40
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .17½
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.16 – .16½	.17 – .18
Ammonium chloride, granular (gray salammoniac)	lb.	.12½ – .13½	.13½ – .14½
Ammonium nitrate	lb.	.08½ – .09½	.10 – .11
Ammonium sulphate	lb.	.07 – .07½	.08½ –
Amylacetate	gal.	—	5.00 –
Amylacetate tech	gal.	—	4.75 – 5.25
Arsenic, oxide, lumps (white arsenic)	lb.	.15½ – .16	.16½ – .17
Arsenic, sulphide, powdered (red arsenic)	lb.	.20 – .21	.22 – .23
Barium chloride	ton	150.00 – 160.00	170.00 – 200.00
Barium dioxide (peroxide)	lb.	.21 – .23	.24 – .25
Barium nitrate	lb.	.09½ – .11	.11 – .12
Barium sulphate (precip.) (blanc fixe)	lb.	.04½ – .05	.05½ – .06
Bleaching powder (see calcium hypochlorite)			
Blue vitriol (see copper sulphate)			
Borax (see sodium borate)			
Brimstone (see sulphur, roll)			
Bromine	lb.	.70 – .90	1.00 – 1.05
Calcium acetate	cwt.	3.50 – 3.55	
Calcium carbide	lb.	.04½ – .04½	.04½ – .05½
Calcium chloride, fused, lump	ton	23.00 – 25.00	30.00 – 40.00
Calcium chloride, granulated	lb.	.01½ – .01½	.02 – .02½
Calcium hypochlorite (bleaching powder)	cwt.	4.00 – 4.25	4.50 – 6.50
Calcium peroxide	lb.	—	1.50 – 1.70
Calcium phosphate, monobasic	lb.	—	.75 – .80
Calcium sulphate, pure	lb.	—	.25 – .30
Carbon bisulphide	lb.	.08 – .09	.10 – .11
Carbon tetrachloride, drums	lb.	.12 – .13	.13½ – .15
Carbonyl chloride (phosgene)	lb.	—	.80 – 1.05
Caustic potash (see potassium hydroxide)			
Caustic soda (see sodium hydroxide)			
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.09 – .09½	.10 – .10½
Chloroform	lb.	.30 – .35	.36 – .38
Cobalt oxide	lb.	—	2.00 – 2.05
Copperas (see iron sulphate)			
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.	—	.65 – .70
Copper sulphate, crystals	lb.	.08 – .09	.09 – .09½
Cream of tartar (see potassium bitartrate)			
Epsom salt (see magnesium sulphate)			
Ethyl Acetate Com. 85%	gal.	1.35 –	1.40 –
Ethyl Acetate pure (acetic ether 98% to 100%)	gal.	—	1.75 –
Formaldehyde, 40 per cent (nominal)	lb.	.36 – .40	.57 – .65
Fusel oil, ref	gal.	—	5.25 – 6.00
Fusel oil, crude (nominal)	gal.	—	
Glauber's salt (see sodium sulphate)			
Glycerine	lb.	—	.26½ – .28½
Iodine, resublimed	lb.	4.30 – 4.35	4.40 – 4.45
Iron oxide, red	lb.	—	.03 – .20
Iron sulphate (copperas)	cwt.	2.90 – 3.10	
Lead acetate, normal	lb.	—	.13½ – .16
Lead arsenate (paste)	lb.	.11 – .12	.13 – .17
Lead nitrate, crystals	lb.	—	.90 – 1.00
Litharge	lb.	.14 – .15	.15½ – .16
Lithium carbonate	lb.	—	1.50 –
Magnesium carbonate, technical	lb.	.12 – .14	.15 – .16
Magnesium sulphate, U. S. P.	100 lb.	3.00 – 3.55	4.00 – 4.50
Magnesium sulphate, commercial	100 lb.	—	3.25 – 3.60
Nickel salt, double	lb.	—	.14 – .16
Nickel salt, single	lb.	—	.16 – .18
Phosgene (see carbonyl chloride)			
Phosphorus, red	lb.	.50 – .55	.60 – .65
Phosphorus, yellow	lb.	—	.35 – .37
Potassium bichromate	lb.	.35 – .37	.45 – .46
Potassium bitartrate (cream of Tartar)	lb.	.52 – .56	.57 – .58
Potassium bromide, granular	lb.	.80 – .85	.90 – .95
Potassium carbonate, U. S. P.	lb.	—	.85 – .88
Potassium carbonate, crude	lb.	.21 – .25	.26 – .28

		Carlots	Less Carlots
Potassium chlorate, crystals	lb.	$0.15 – $0.16	$0.21 –
Potassium hydroxide (caustic potash)	lb.	.28 – .29	.31 – .35
Potassium iodide		—	3.35 – 3.60
Potassium nitrate	lb.	.15 – .17	.19 – .21
Potassium permanganate	lb.	.75 – .80	.85 – .95
Potassium prussiate, red	lb.	.90 – 1.00	1.05 –
Potassium prussiate, yellow	lb.	.32 – .36	.35 – .36
Potassium sulphate (powdered)	ton	225.00 – 240.00	
Rochelle salts (see sodium potas. tartrate)			
Salammoniac (see ammonium chloride)		—	
Sal soda (see sodium carbonate)		—	
Salt cake	ton	30.00 – 32.00	34.00 – 36.00
Silver cyanide (nominal)	oz.	—	1.25 –
Silver nitrate (nominal)	oz.	—	.74 – .76
Soda ash, light	100 lb.	—	3.50 – 3.60
Soda ash, dense	100 lb.	—	3.55 – 3.65
Sodium acetate	lb.	.08½ – .09	.09½ – .12
Sodium bicarbonate	100 lb.	2.45 – 2.60	2.75 – 3.50
Sodium bichromate	lb.	.30 – .33	.34 – .36
Sodium bisulphate (nitre cake)	ton	7.00 – 7.50	8.00 – 10.00
Sodium bisulphite Powered	lb.	.06 – .06½	.07 – .10½
Sodium borate (borax)	lb.	.09 – .10	.11 – .12
Sodium carbonate (sal soda)	100 lb.	1.60 – 1.80	1.80 – 2.00
Sodium chlorate	lb.	.10 – .10½	.10½ – .11
Sodium cyanide, 96-98 per cent	lb.	.24 – .25	.26 – .27
Sodium fluoride	lb.	.18 –	.19 – .20
Sodium hydroxide (caustic soda)	100 lb.	4.25 – 6.00	6.25 – 6.50
Sodium hyposulphite	lb.	—	.03 – .04
Sodium molybdate	lb.	2.50 –	3.25½ –
Sodium nitrate	100 lb.	3.00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.16 – .18	.19 – .20
Sodium peroxide, powdered	lb.	.32 – .35	.35 – .40
Sodium phosphate, dibasic	lb.	.03½ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	—	.39 – .40
Sodium prussiate, yellow	lb.	.23 – .27	.31 – .32
Sodium silicate, solution (40 deg.)	lb.	.01½ – .01½	.02 – .02½
Sodium silicate, solution (60 deg.)	lb.	.02½ – .03	.04 – .05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.60 – 1.70	1.75 – 2.50
Sodium sulphide, crystal, 60-62 percent (conc)	lb.	.09 – .10	.10½ – .11
Sodium sulphite, crystals	lb.	.03½ –	.04 – .06
Strontium nitrate, powdered	lb.	.17½ – .18½	.19 – .20
Sulphur chloride	lb.	.05½ –	.06 –
Sulphur, crude	ton	22.00 –	
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	3.35 –	3.40 – 3.65
Sulphur, roll (brimstone)	100 lb.	3.20 –	3.30 – 3.40
Tin bichloride (stannous)	lb.	.42½ –	.46 – .50
Tin oxide	lb.	.60 – .63	.65 –
Zinc carbonate, precipitate	lb.	.16 – .18	.19 – .20
Zinc chloride, gran.	lb.	.13 – .13½	.13½ – .17
Zinc cyanide	lb.	.49 –	.50 – .60
Zinc dust	lb.	.12½ –	.13 – .15
Zinc oxide, U. S. P.	lb.	.18 – .19	.20 – .21
Zinc sulphate	lb.	.03½ – .03½	.04 – .06

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.40 —	$1.50
Alpha naphthol, refined	lb.	1.60 —	1.70
Alpha naphthylamine	lb.	.55 —	.60
Aniline oil, drums extra	lb.	.32 —	.38
Aniline salts	lb.	.40 —	.45
Anthracine, 80% in drums (100 lb.)	lb.	.90 —	1.00
Benzaldehyde (f.f.c.)	lb.	2.00 —	2.10
Benzidine, base	lb.	1.35 —	1.40
Benzidine, sulphate	lb.	1.15 —	1.25
Benzoic acid, U.S.P.	lb.	.90 —	1.00
Benzoate of soda, U.S.P.	lb.	.80 —	.90
Benzol, pure, water-white, in drums (100 lb.)	gal.	.27 —	.40
Benzol, 90%, in drums (100 lb.)	gal.	.25 —	.31
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech.	lb.	.25 —	.35
Beta naphthol benzoate (nominal)	lb.	3.50 —	4.00
Beta naphthol, sublimed (nominal)	lb.	.90 —	1.10
Beta naphthol, tech (nominal)	lb.	.70 —	.90
Beta naphthylamine, sublimed	lb.	2.25 —	2.40
Cresol, U. S. P., in drums (100 lb.)	lb.	.18 —	.19
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	1.10 —	1.20
Cresylic acid, 95-97%, dark, in drums	gal.	1.00 —	1.05
Cresylic acid, 50%, first quality, drums	gal.	.65 —	.75
Dichlorbenzol	lb.	.08 —	.10
Diethylaniline	lb.	1.50 —	1.60
Dimethylaniline	lb.	1.35 —	1.55
Dinitrobenzol	lb.	.30 —	.37
Dinitroclorbenzol	lb.	.30 —	.35
Dinitronaphthaline	lb.	.45 —	.55
Dinitrophenol	lb.	.40 —	.45
Dinitrotoluol	lb.	.40 —	.45
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38 —	.40
Diphenylamine (nominal)	lb.	.80 —	.85
H-acid (nominal)	lb.	2.25 —	2.50
Metaphenylenediamine	lb.	1.15 —	1.30
Monochlorbenzol	lb.	.18 —	.20
Monoethylaniline	lb.	2.00 —	2.40
Naphthaline crushed, in bbls. (250 lb.)	lb.	.17 —	
Naphthaline, flake	lb.	.17 —	.18
Naphthaline, balls	lb.	.16 —	.18
Naphthionic acid, crude	lb.	.75 —	.85
Nitrobenzol	lb.	.14 —	.19
Nitro-naphthaline	lb.	.40 —	.50
Nitro-toluol	lb.	.18 —	.25
Ortho-amidophenol	lb.	3.25 —	4.25
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	.80 —	1.25
Ortho-nitro-toluol	lb.	.25 —	.40
Ortho-toluidine	lb.	.35 —	.45
Para-amidophenol, base	lb.	2.50 —	3.00
Para-amidophenol, HCl	lb.	2.50 —	3.00
Para-dichlor-benzol	lb.	.08 —	.12
Paranitraniline	lb.	1.50 —	1.55
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	2.60 —	3.00
Paratoluidine	lb.	2.00 —	2.50
Phthalic anhydride	lb.	.65 —	.75
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12 —	.20
Pyridin	gal.	2.00 —	3.50
Resorcin, technical	lb.	4.25 —	4.50
Resorcin, pure	lb.	6.25 —	6.75

Salicylic acid, tech., in bbls. (110 lb.)	lb.	$0.50	—	$0.52
Salicylic acid, U. S. P.	lb.	.50	—	.60
Salol	lb.	.90	—	1.00
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.25	—	.31
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.19	—	.24
Sulphanilic acid, crude	lb.	.32	—	.35
Toluidine	lb.	1.70	—	2.50
Toluidine, mixed	lb.	.45	—	.55
Toluol, in tank cars	gal.	.28	—	....
Toluol, in drums	gal.	.29	—	.32
Xylidine. drums, 100 gal.	lb.	.50	—	.65
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	....
Xylol, commercial, in drums, 100 gal.	gal.	.37	—	.45
Xylol, commercial, in tank cars	gal.	.23	—	.27

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.36	—	$0.39
Beeswax, refined, light	lb.	.39	—	.40
Beeswax, white pure	lb.	.63	—	.68
Carnauba, No. 1 (nominal)	lb.	1.00	—	1.05
Carnauba, No. 2, regular (nominal)	lb.	.85	—	.88
Carnauba, No. 3, North Country (nominal)	lb.	.43	—	.44
Japan	lb.	.21	—	.22
Montan, crude	lb.	.23	—	.25
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.09	—	.09½
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.09½	—	.10
Paraffine waxes, refined, 118-120 m.p.	lb.	.11½	—	.12½
Paraffine waxes, refined, 128-130 m.p.	lb.	.14½	—	.15
Paraffine waxes, refined, 133-135 m.p.	lb.	.16½	—	.17
Paraffine waxes, refined, 135-137 m.p.	lb.	.17½	—	.18½
Stearic acid, single pressed	lb.	.25	—	.26
Stearic acid, double pressed	lb.	.26	—	.27
Stearic acid, triple pressed	lb.	.27	—	.28

NOTE—Quotations on paraffine waxes are nominal.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$1.80
Pine oil, pure, dest. dist.	gal.	1.60
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 cars f.o.b. Jacksonville, Fla.	gal.	.35
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1.75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$17.50	—	$18.00
Rosin E-I	280 lb.	18.50	—	19.75
Rosin K-N	280 lb.	20.00	—	21.00
Rosin W. G.-W. W.	280 lb.	21.25	—	23.00
Wood rosin, bbl.	280 lb.	17.00	—	17.00
Spirits of turpentine	gal.	1.75	—	
Wood turpentine, steam dist.	gal.	1.55	—	1.60
Wood turpentine, dest. dist.	gal.	1.40	—	1.50
Pine tar pitch, bbl.	200 lb.	....	—	8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	—	15.50
Retort tar, bbl.	500 lb.	15.00	—	15.50
Rosin oil, first run	gal.	.87	—	.89
Rosin oil, second run	gal.	.89	—	.92
Rosin oil, third run	gal.	1.04	—	1.05
Rosin oil, fourth run	gal.	1.12	—	1.12

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.40
70-72 deg., steel bbls. (85 lb.)	gal.	.38
68-70 deg., steel bbls. (85 lb.)	gal.	.37
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.29

Crude Rubber

Para—Upriver fine	lb.	$0.36½	—	$0.37½
Upriver coarse	lb.	.26½	—	.27½
Upriver caucho ball	lb.	.27½	—	.28½
Plantation—First latex crepe	lb.	.36	—	.37
Ribbed smoked sheets	lb.	.35	—	.36
Brown crepe, thin, clean	lb.	.36	—	.37
Amber crepe No. 1	lb.	....	—	.40

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls.	lb.	$0.18½	—	$0.20
Castor oil, AA, in bbls.	lb.	.20	—	.22
China wood oil, in bbls.	lb.	.18½	—	.19½
Cocoanut oil, Ceylon grade, in bbls.	lb.	.17½	—	.18½
Cocoanut oil, Cochin grade, in bbls (nominal)	lb.	.18½	—	.19½
Corn oil, crude, in bbls.	lb.	.17	—	.18
Cottonseed oil, crude (f.o.b. mill)	lb.	.15½	—	.16
Cottonseed oil, summer yellow	lb.	.18½	—	.19
Cottonseed oil, winter yellow	lb.	.21	—	.22
Linseed oil, raw, car lots (domestic)	gal.	1.57	—	1.67
Linseed oil, raw, tank cars (domestic)	gal.	1.52	—	1.62
Linseed oil, boiled, car lots (domestic)	gal.	1.60	—	1.70
Olive oil, commercial	gal.	3.10	—	3.25
Palm, Lagos	lb.	.12½	—	.13½
Palm, bright red	lb.	.13	—	.13½
Palm, Niger	lb.	.11	—	.12
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.13	—	.15
Peanut oil, refined, in bbls.	lb.	.22	—	.24
Rapeseed oil, refined in bbls.	gal.	1.70	—	1.72
Rapeseed oil, blown, in bbls. N. Y.	gal.	1.80	—	1.85
Soya bean oil (Manchurian), in bbls.	lb.	.17	—	.18
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.12½	—	.13½

FISH

Winter pressed Menhaden	gal.	$1.17	—	$1.18
Yellow bleached Menhaden	gal.	1.20	—	1.22
White bleached Menhaden	gal.	1.23	—	1.24
Blown Menhaden	gal.	1.30	—	1.32

Miscellaneous Materials

All f. o. b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$22.00	—	25.00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	18.00	—	20.00

Barytes, crude, 88%@94% ba., Kings Creek	net ton	8.00	—	10.00
Barytes, ground, white, f.o.b. Cartersville, Ga.	net ton	23.00	—	25.00
Barytes, ground, off-color, f.o.b. Cartersville	net ton	16.00	—	19.00
Barytes, crude, 88%@94% ba., Cartersville	net ton	12.00	—	....
Blanc fixe, dry	lb.	.05½	—	.06
Blanc fixe, pulp	net ton	60.00	—	80.00½
Casein	lb.	.15	—	.18
Chalk, domestic, extra light	lb.	.05	—	.06
Chalk, domestic, light	lb.	.04½	—	.05½
Chalk, domestic, heavy	lb.	.04	—	.05
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.05	—	.06
Chalk, English, dense	lb.	.04½	—	.05
China clay (Kaolin) crude f.o.b. Virginia points	net ton	8.00	—	12.00
China clay (Kaolin) ground, f.o.b. Virginia points	net ton	15.00	—	40.00
China clay (Kaolin), imported, lump	net ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	net ton	30.00	—	60.00
Feldspar, crude, f.o.b. Maryland and North Carolina points	gross ton	7.50	—	8.00
Feldspar, crude, f.o.b. Maine	net ton	7.50	—	10.00
Feldspar, ground, f.o.b. Baltimore	net ton	22.00	—	25.00
Feldspar, ground, f.o.b. North Carolina	net ton	16.00	—	20.00
*Feldspar, ground, f.o.b. N. Y. State	net ton	16.00	—	20.00
Fuller's earth, granular, f.o.b. Fla.	net ton	25.00	—	....
Fuller's earth, powdered, f.o.b. Fla.	net ton	18.00	—	....
Fuller's earth, imported, powdered	net ton	35.00	—	40.00
Graphite (dust polish grade 30%) Ashland, Ala.	lb.	....	—	.01
Graphite (dust facing grade 50%) Ashland, Ala.	lb.	....	—	.02
Graphite, crucible, 80% carbon Ashland, Ala.	lb.	....	—	.05
Graphite, crucible, 90% carbon Ashland, Ala.	lb.	....	—	.10
Graphite, crucible, 85% carbon	lb.	....	—	.08
Graphite, crucible, 88% carbon	lb.	....	—	.09½
Graphite, crucible, 90% carbon	lb.	....	—	.10½
Pumice stone, imported, lump	lb.	.04	—	.50
Pumice stone, domestic, lump	lb.	.06	—	....
Pumice stone, ground	lb.	.04	—	.07
Quartz (acid tower) fist to head, f.o.b. Baltimore	net ton	....	—	10.00
Quartz (acid tower) 1½@2 in., f.o.b. Baltimore	net ton	....	—	14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	....	—	17.00
Quartz, lump, f.o.b. North Carolina	net ton	5.00	—	7.50
Shellac, orange, fine	nominal lb.	1.35	—	1.40
Shellac, orange, superfine	lb.	1.45	—	1.50
Shellac, A. C. garnet	lb.	1.05	—	1.15
Shellac, T.N.	lb.	1.20	—	1.30
Soapstone	ton	15.00	—	25.00
Talc, paper-making grades, f.o.b. Vermont	ton	9.50	—	14.00
Talc, roofing grades, f.o.b. Vermont	ton	8.00	—	9.00
Talc, rubber grades, f.o.b. Vermont	ton	9.00	—	15.00
Talc, powdered, Southern, f.o.b. cars	ton	12.00	—	15.00
Talc, imported	ton	60.00	—	70.00
Talc, California Talcum Powder grade, f.o.b.	ton	20.00	—	35.00

Refractories

Bauxite brick, 56@ alumina, f.o.b. Pittsburgh	1,000	$145		
Chrome brick, f.o.b. Chester, Pa., carlots	net ton	90-		100
Chrome brick, 9-in. strs. and sizes, f.o.b. Baltimore	net ton	80-		90
Fire clay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000	45-		53
Fire clay brick, 1st quality, f.o.b. St. Louis	1,000	45-		
Fire clay brick, 1st quality, f.o.b. New Jersey	1,000	75-		
Fire clay brick, 2d quality, 9-in. shapes f.o.b. Pennsylvania, Ohio and Kentucky works	1,000	40-		.
Magnesite brick, 9 in. straights, f.o.b. Baltimore	net ton	90		
Magnesite brick, 9-in. sizes and shapes larger than 9-in.		Regular extras		
Magnesite brick, f.o.b. Chester	1,000	90-		100
Silica brick, 9-in. and 9-in. sizes, f.o.b. works, Chicago district	net ton	55-		.
Silica brick, f.o.b. Birmingham	1,000	51-		55
Silica brick, f.o.b. Mt. Union, Pa.	1,000	50-		55

Ferro-Alloys

All f.o.b. Works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon, carlots	lb.	.19	—	.20
Ferro-chrome, per lb. of Cr. contained, 4-6% carbon, carlots	lb.	.20	—	.21
Ferro-manganese, 76-80% Mn.	gross ton	200.00	—	250.00
Spiegeleisen, 18-22% Mn.	gross ton	75.00	—	....
Ferro-molybdenum, 50-60% Mo, per lb. of Mo.	lb.	2.50	—	3.00
Ferro-silicon, 10-15%	gross ton	60.00	—	65.00
Ferro-silicon, 50%	gross ton	80.00	—	90.00
Ferro-silicon, 75%	gross ton	150.00	—	160.00
Ferro-tungsten, 70-80%, per lb. of contained W.	lb.	.90	—	1.10
Ferro-uranium, 35-50% of U, per lb. of U content	lb.	7.00	—	....
Ferro-vanadium, 30-40% per lb. of contained V.	lb.	6.50	—	7.75

Ores and Semi-finished Products

All f.o.b. Mines, Unless Otherwise Stated

Chrome ore, Calif. concentrates, 50% min. Cr_2O_3	unit	.60		.65
Chrome ore, 40%, min., Cr_2O_3 f.o.b. Atlantic Seaboard	unit	.70	—	.85
Coke, foundry, f.o.b. ovens	net ton	18.00	—	19.00
Coke, furnace, f.o.b. ovens	net ton	17.50	—	18.50
*Coke, petroleum, refinery, Atlantic Seaboard	net ton	24.00		
Fluor spar, lump, f.o.b. Tonuco, New Mexico	net ton	17.50	—	
Fluor spar, standard, domestic washed gravel	net ton	....	—	25.00
Ilmenite, 52% TiO_2, per lb. ore	lb.	.02	—	....
Manganese Ore, 50% Mn, c.i.f. Atlantic seaport	unit	.85	—	.90
Manganese ore, chemical (MnO_2)	gross ton	75.00	—	85.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.85	—	....
Monazite, per unit of ThO_2	unit	42.00	—	....
Pyrites, Spanish, fines, c.i.f., Atlantic seaport	unit	.12	—	....
Pyrites, Spanish, furnace size, c.i.f., Atlantic seaport	unit	.16½	—	....
Pyrites, Spanish, run of mines, c.i.f., Atlantic seaport	unit	.12	—	.14
Pyrites, domestic, fines	unit	.12	—	.14
Rutile, 95% TiO_2 per lb. ore	lb.	.20	—	.25
Tungsten, Scheelite, 60% WO_3 and over, per unit of WO_3	unit	7.00	—	....
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50	—	7.50
Uranium Ore (Carnotite) per lb. of U_3O_8	lb.	2.75	—	3.00
Uranium oxide, 96% per lb. contained U_3O_8	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	12.00	—	14.00
Vanadium ore per lb. of V contained	lb.	1.00	—	2.50
Zircon, washed, iron free	lb.	.10	—	....

*Nominal

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

California

SACRAMENTO — The City Comrs. will receive bids about Aug. 15 for the construction of a filtration plant, cost, $1,618,000. Plans include an intake, pier and conduits, $155,000; filters, head house and pump, $225,000; filtered water basin, $115,000; coagulating basins, $190,000; coagulating house, $75,000, etc. M. J. Desmond, city clk. C. J. Hyde, engr.

Connecticut

BRIDGEPORT — The Cave Welding & Mfg. Co., 303 Center St., has awarded the contract for the construction of a 1-story, 42x93-ft. mill addition to welding plant on Center St., to Canning & Leary, Harris Bldg., New London. Estimated cost, $18,000.

District of Columbia

WASHINGTON—The Bureau of Yards & Docks, Navy Dept., received the only bid for additions and alterations to the Aeronautical Engine Testing Laboratory, here, from Hyde & Baxter, 711—13th St., N. W., $14,990. Noted June 16.

Georgia

LA GRANGE — Swift & Co., United States Navy Yard, Chicago, has awarded the contract for the construction of a 1-story, 200x350-ft. fertilizer plant, to George Johnson & Son. Estimated cost, $250,000.

Indiana

VALPARAISO — The McGill Metal Co. plans to build a factory for the manufacture of bronze die castings. Estimated cost, $100,000. Charles Meier, engr.

Iowa

LAWLER—The Bd. Educ. plans to convert grade school into a high school. Chemical and physical laboratories will be installed in same. Estimated cost, $100,000. Frank Tustison, 355 Auditorium Bldg., Minneapolis, Minn., engr. Jacobson & Jacobson, Owatonna, Minn., archts.

Maryland

SPARROWS POINT — The Bethlehem Steel Co. is having plans prepared for the construction of a 2-story, 48x140-ft. hospital. Laboratory equipment will be installed in same. Estimated cost, $150,000. J. E. Sperry, 409 Calvert Bldg., Baltimore, archt.

Massachusetts

HOLYOKE—J. & W. Jolly, Inc., South East St., has awarded the contract for the construction of a 2-story, 100x100-ft. foundry to the Casper Ranger Constr. Co., Bond St. Estimated cost, $75,000.

LOWELL — The Saco-Lowell Shop, 77 Franklin St., Boston, has awarded the contract for the construction of a 1-story, 130 x 140-ft. foundry on Walker St., to D. H. Walker, 529 Dutton St. Estimated cost, $100,000.

WILLIMANSETT—The New England Tire & Rubber Co., Springfield, is having plans prepared for the construction of a large factory for the manufacture of tires and tubes, here. F. H. Callahan, pres.

Minnesota

JORDAN—The Bd. Educ. has awarded the contract for the construction of a 2-story, 67 x 110-ft. high school, to the Hracker Constr. Co., 638 Builders' Exch. Bldg., Minneapolis. A chemical laboratory will be installed in same. Estimated cost, $100,000. Noted May 19.

MINNEAPOLIS—The State Bd. of Control, State Capitol, St. Paul, received bids for the construction of a 3-story addition to the chemistry building at the University of Minnesota, from the Gauger-Korsmo Constr. Co., 301 Endicott Bldg., St. Paul, $225,994; James Peterson, 3152 Tenth Ave., S., $247,800; J. & W. A. Elliott, 906 Lumber Exch. Bldg., $254,725.

Missouri

ST. LOUIS — The St. Louis Malleable Casting Co., 7300 North Conduit Ave., is building additions and improvements to its present plant. Estimated cost, $500,000.

New York

FALCONER—The Jamestown Malleable Products Corp., Jamestown, plans to build a 400x400-ft. malleable iron foundry. Estimated cost, $300,000.

MARCY—The State Hospital Comn. will soon receive bids for the construction of a sewerage and water supply system including filter beds, chlorinating apparatus, settling tank, chlorinating building, etc., for the Utica State Hospital here.

SYRACUSE—The Atmospheric Nitrogen Corp., Milton Ave., has awarded the contract for the construction of a 1-story atmospheric nitrogen plant on Willis Ave., to the J. G. White Eng. Corp., 43 Exch. Pl., New York City. Estimated cost, $500,000.

North Dakota

HANKINSON—The Bd. Educ. plans to build a 2-story, 65x130-ft. high school. A chemical laboratory will be installed in same. Estimated cost, $135,000. Terry Schulte Eng. Co., 484 Endicott Bldg., St. Paul, Minn., engr. Buechner & Orth, Shubert Bldg., St. Paul, Minn., archts. Noted April 14.

Ohio

AKRON—The S. & O. Engraving Co., 330 South High St., has awarded the contract for the construction of a 2-story, 40x150-ft. office and laboratory building on South High St., to the Carmichael Constr. Co., 524 Hamilton Bldg. Estimated cost, $75,000. Noted March 17.

CHAGRIN FALLS—The Adams Bag Co. is having plans prepared for the construction of a 3-story paper mill extension. Estimated cost, $100,000. Ernest McGeorge, 1900 Euclid Ave., Cleveland, archt. and engr.

CLEVELAND—The city has awarded the contract for 23 hydraulic operated sluice gates for the easterly sewage treatment plants, to the Coffin Valve Co., Wade Bldg., G. B. Gascoigne, City Hall, engr.

Pennsylvania

HORRELL (Canoe Creek P. O.) — The Standard Powder Co., Philadelphia, has purchased a 700 acre site here and will build twenty-five 1-story buildings, each to be used for one step in the manufacture of powder. Estimated cost, $1,000,000. Work will be done by day labor.

JEANETTE—The Amer. Window Glass Co., Farmers Bank Bldg., Pittsburgh, has awarded the contract for the construction of a 1- and 2-story furnace building, to the Hughes-Foulkrod Co., Oliver Bldg., Pittsburgh. Estimated cost, $300,000.

Tennessee

KINGSPORT—The Grant Leather Corp. is building a 2-story, 275x500-ft. factory. Estimated cost, $300,000.

Texas

PLANO—The city has awarded the contract for the construction of 2 sewage disposal plants equipped with chlorinators, etc., to Dalton & Campbell, 1915½ Main St., Dallas, at $31,254.

Virginia

RICHMOND—The Baughman Stationery Co., 1320 Broad St., West, is having plans prepared for the construction of a 2-story, 173x227-ft. factory on Marshall and Graham Sts. Estimated cost, $200,000. Carneal & Johnson, Chamber of Commerce Bldg., archts.

Washington

WENATCHEE — The city has awarded the contract for the construction of a filtration and pumping plant, to the California Filter Co., Spokane. Estimated cost, $60,000. Noted May 26.

Wisconsin

MILWAUKEE—The Amer. Metal Products Co., 671 Kinnickinnic Ave., will soon receive bids for the construction of a 1-story, 80x200-ft. machine shop and foundry on Burnham St. Noted June 30.

MILWAUKEE—Scott & Mayer, archts., Colby Abbott Bldg., will soon award the contract for the construction of a 2-story, 70x100-ft. varnish factory and a 60x112-ft. warehouse on Lake St., for the Patton Paint Co., 213 Lake St.

Quebec

THREE RIVERS—Laflour & McDougall, 107 St. James St., Montreal, will soon receive bids for the construction of a steel plant on Normand Blvd. Estimated cost, $750,000.

Ontario

TILLBURY—The Tillbury Brick & Tile Co. has awarded the contract for the construction of a 1-story brick plant, to the W. F. Sparling Co., 120 Bay St., Toronto. Estimated cost, $30,000.

TORONTO—The Sunlight Soap Co., Eastern Ave., will build a 3-story soap factory. Estimated cost, $350,000. Work will be done by day labor.

Coming Meetings and Events

AMERICAN CERAMIC SOCIETY will hold its summer meeting at the La Salle Hotel in Chicago, Aug. 16, 17 and 18.

AMERICAN CHEMICAL SOCIETY will hold its fall meeting in Chicago, Sept. 7 to 10 inclusive.

AMERICAN ELECTROCHEMICAL SOCIETY will hold its Fall meeting in the Hotel Statler, Cleveland, Ohio, Sept. 30, Oct. 1 and 2.

AMERICAN FOUNDRYMEN'S ASSOCIATION will meet in Columbus, Ohio, Oct. 4 to 8 inclusive.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its one hundred and twenty-second meeting Aug. 20 to Sept. 3, at Lake Superior.

AMERICAN MINING CONGRESS will hold its next convention in Denver Nov. 15.

AMERICAN PHYSICAL SOCIETY will hold a meeting Nov. 27 at the Case School of Applied Science, Cleveland, and the annual meeting, beginning Dec. 28, at Chicago, the latter being the occasion of the special quadrennial meeting of the American Association for the Advancement of Science and the Affiliated Societies.

AMERICAN STEEL TREATERS' SOCIETY, Chicago, will hold its second annual convention and exhibit, combined with the convention of the Steel Treating Research Society of Detroit, Mich., in the Coliseum Museum, Philadelphia, Pa., Sept. 14 to 18 inclusive.

FOREST PRODUCTS LABORATORY will hold its decennial celebration at Madison, Wis., July 22 and 23, 1920.

INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

INSECTICIDE AND DISINFECTANT MANUFACTURERS' ASSOCIATION will hold its midsummer meeting at Boston, July 15 and 16.

IRON AND STEEL INSTITUTE (British) will hold its autumn meeting at Cardiff by invitation of the Ironmasters and Steel Manufacturers of South Wales and Monmouthshire. The date of the meeting will be Tuesday, Sept. 21, for the assembling of the members at Cardiff, and the formal proceedings will open on the morning of Wednesday, Sept. 22.

SIXTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in the Grand Central Palace, New York City, Sept. 20 to 25.

TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its fall meeting at Saratoga Springs, N. Y., Sept. 1, 2 and 3.